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PROVISIONAL SPECIFICATION.

Improvements relating to Machines for the Production of
Transmission Chains.

We, THE RENOLD AND COVENTRY CHAIN COMPANY LIMITED, a Company organised under the laws of Great Britain, JAMES HENRY ICKE, a British Subject, and CLARENCE JAMES Potts, a British Subject, all of Spon End Works, Coventry, Warwickshire, do hereby declare the nature of this invention to be as follows:—

10 This invention relates to machines for assembling the components of a jointed link chain, of the kind in which components during assembly are located with the axes of all the joints lying in a horizontal plane—that is to say, the length of the chain is horizontal and the outer link plates are vertically on edge.

The object of the present invention is to provide a machine of this kind for 20 assembling jointed link chains of the roller type the components of which consist of inner link combinations already assembled, bearing pins, and outer link plates.

25 According to one feature of the present invention inner link combinations are fed to an intermittently moving locating means which locates them in correct spaced relationship with the axes of all 30 their bushes in a horizontal plane and moves them step-by-step; bearing pins are inserted into the bushes and subsequently outer link plates are placed in position 35 at the sides of the succession of inner link combinations and forced on to the bearing pins already within the bushes of the inner link combinations by pressure applied laterally to the outer link plates.

40 According to a further feature of the invention the locating means comprises a horizontally-disposed feed slide having rack teeth directed downwardly and surmounting a smooth horizontal guideway upon which the inner link combinations 45 rest, means being provided for moving the slide in a cyclical path comprising a forward movement along the horizontal guideway with its teeth in proximity to the guideway, an upward movement, a return horizontal movement in the raised position, and a downward movement to bring its teeth once more into proximity to the guideway at the beginning of its 50 [Price 1/-]

forward horizontal movement. The pitch of the rack teeth is equal to the pitch of the chain to be assembled, and it will be appreciated that inner link combinations placed on the guideway one at a time at the rear end of the feed slide will be engaged by the rack teeth, fed forward along it during the forward movement of the feed slide, left stationary upon the guideway during the upward and return movements of the slide and re-engaged by different teeth of the feed slide, and fed forward again during the ensuing forward movement. The amplitude of the horizontal movement of the feed slide is equal to two chain pitches whereby a succession of inner link combinations are spaced apart along the guideway with the axes of their adjacent bushes separated by a distance equal to the pitch of the chain, all the combinations in the succession being fed forward a distance equal to two chain pitches during each forward movement of the slide.

A further feature of the invention consists in improved means for locating the ends of the bearing pins during the process of forcing an outer link plate over them, which consists in locating pins having pointed ends which are mounted resiliently in the ram which applies the pressure to the outer link plate and which are of a diameter to fit the holes in these plates, the pointed ends entering correspondingly-shaped recesses centrally disposed in the end faces of the bearing pins. When the ram advances the locating pins first pass through the holes in the outer link plates and locate these plates correctly, and their pointed ends then enter the recesses in the ends of the bearing pins and bring these pins into register with the holes. Further movement of the ram causes the locating pins to retreat into the ram against spring pressure, and finally the ram forces the side plates over the ends of the bearing pins.

The machine may comprise a pair of rams arranged to apply pressure from both sides to each inner link combination in turn whereby they are all brought to a definite width prior to the assembly therewith of the outer link plates. In the

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preferred design this is accomplished by employing one moving ram and a fixed anvil.

The machine may be arranged to press each pair of outer link plates on to the bearing pins simultaneously, there being two rams opposite to one another for this purpose, each preferably provided with pointed locating pins such as are referred to above. It is preferred, however, to apply the outer link plates in more than one stage, those on one side being applied at one station, and those on the other side being applied at a subsequent station. In this case two further rams oppositely disposed are provided which finally complete the pressing on of each pair of outer link plates and bring them all to a uniform separation.

20 The invention further comprises improved means whereby the failure to feed a component, the feed of a faulty component or the presenting of a component in an incorrect attitude will automatically cause the machine to stop.

A preferred embodiment of the invention will now be described by way of example. The assembly of the chain takes place on a horizontal guideway having a central rib on which the rollers 30 of the chain rest, and two grooves one on either side of the rib for the link plates. The various tools are actuated by cams mounted upon a cam shaft arranged parallel to the length of the guideway. Inner link combinations are fed in a continuous stream from a suitable hopper on to the guideway at one end. From here they are fed along the guideway intermittently one at a time in proper spaced relationship, and at successive stations the following operations are performed:

(1) The inner link combinations are brought to a uniform width by means of 45 a ram which approaches it from the side and cooperates with a fixed anvil, the closed distance between the face of the ram and the face of the anvil being equal to the desired width of these components. Thus, any inner links which are wider than the standard dimensions are reduced in width by this ram.

(2) Two jointing pins are fed into adjacent bushes of the inner links.

55 (3) An outer link plate is fed into position with its holes opposite to the bearing pins lying in the contiguous bushes of two inner links and is forced over the two jointing pins by a ram which moves in from the side.

(4) An outer link plate is fed on the other side of the chain and forced on to the ends of the jointing pins in the same way as the outer link plates first described.

65 (5) Two rams are moved in from oppo-

site sides to complete the pressing of the outer link plates over the jointing pins and to bring the outer link plates to a definite constant separation.

The feeding forward of the components along the guideway is effected by means of a feed slide in the form of a rack having its teeth downwardly directed and mounted above the guideway. The pitch of the rack teeth is the same as that of

70 the chain to be assembled and it extends forwardly along the guideway to a point in advance of the Station No. 3 at which the first outer link plate is supplied. This feed slide or rack has two movements,

75 namely, a horizontal forward and return movement and an up and down movement, these movements being imparted to it by two separate cams. It begins its forward

80 movement from a position in which its rear end is immediately over the point to which the inner links are fed, and the extent of this forward movement is equal to twice the pitch of the chain. This forward feed movement is performed

85 while the rack is in its lower position. At the end of the forward movement the rack is raised and is returned to its starting point in the raised position whereupon it descends to its original level. It will be appreciated that if an inner link is placed upon the rear end of the guideway the rack in descending will enter one of its teeth between the two rollers, whereupon during the forward movement at

90 the lower level the inner link will be carried along the guideway a distance equal to twice the chain pitch. The upward movement is sufficient to bring the tips of the teeth of the rack clear of the rollers

95 so that when the rack returns in its raised position it will leave the inner link at the point to which it has been moved. During this return movement a second inner link will have been fed on to the guideway and this also will be engaged by a tooth of the rack when the rack descends,

100 while a tooth further along the rack will also engage the first inner link. The next forward movement of the rack will therefore feed both inner links in proper spaced relation a further step of movement along the guideway, and these operations will be continued indefinitely with

105 the result that a succession of inner links will move step-by-step along the guideway in proper spaced relation with one another.

110 As each inner link reaches Station No. 1 a ram approaches it from one side. It is operated by a cam through a lever and it cooperates with a fixed anvil placed on the other side of the guideway, the faces of the ram and of the anvil approaching

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desired finished width of the inner links. Thus, any inner link which is too wide is brought to the standard width.

At Station No. 2 the jointing pins are fed from a hopper through two chutes side-by-side which present two pins in a horizontal position at the correct distance apart to the upper end of a reservoir or magazine. These pins are taken two at a time from the lower end of the reservoir by plungers which insert them into the bushes of the inner links. These plungers are carried by a ram in which they slide under spring pressure. At the opposite side of the guideway is a similar ram carrying two similar plungers which also slide within the ram under spring pressure. The movement of the two rams is effected by separate cams through suitable levers and links and is such that the plungers on the side of the guideway remote from the reservoir (the centering plungers) first pass through the bushes, the plungers on the reservoir side (inserting plungers) being in their retired position. The inserting plungers begin their forward movement while the centering plungers are still within the bushes, and they remove two bearing pins from the lower ends of the piles within the reservoir and bring their ends into contact with the ends of the centering plungers. Thereupon the centering plungers recede in concert with the advance of the inserting plungers until the pins are completely within the bushes. Thereupon the two rams separate and the feed rack advances. It will be appreciated that the function of the centering plungers is to ensure that the bushes shall be correctly located to receive the bearing pins and to guide the bearing pins into the bushes.

The attachment of the hopper feed chutes to the pin reservoir is off-set, and the pins to be fed are transferred from the feed tube position to the reservoir position by a slide of a thickness corresponding to the length of the pins, which acts as a gauge to prevent pins of incorrect length being passed to the reservoir.

At station No. 3 outer link plates are fed to one side of the guideway. The link plates are arranged in the form of a stack in a magazine, the lower end of which is curved so that each link plate emerges from the extremity of the magazine on edge with the line joining its holes horizontal. On emerging from the extremity of the magazine each plate is fed down to a position on the guideway where it spans the gap between two adjacent inner links with its holes opposite the two bushes. A fixed anvil is arranged on the side of the guideway opposite to this link plate and a ram is

guided so as to force it on to the bearing pins supported by the anvil. This ram has two centering plungers sliding within it against spring pressure and the free ends of these plungers are in the form of obtuse angled conical points. The end faces of the bearing pins are formed with corresponding countersinks or recesses. As the ram advances the ends of the centering plungers pass through the holes in the link plate thus centering these holes by reason of the fact that the locating pins fit them closely. Thereupon the points of the plunger enter the recesses in the ends of the bearing pins and bring these pins into accurate alignment with the holes in the link plate. The ram continues to advance, the plungers retreat into the ram against spring pressure, and finally the face of the ram engages the link plate and presses it over the ends of the bearing pins.

At Station No. 4 there is a similar arrangement of link plate, magazine, anvil and ram with centering plungers, whereby the link plates on the other side of the chain are added. From this point the chain is fully assembled and it finally passes under a sprocket wheel which is rotated intermittently in time with the step-by-step movements of the feed rack.

The two rams just described are operated by cams which are so adjusted that the outer link plates are not pushed to their final positions over the bearing pins. The final operation consists in completing the pressing on of the outer link plates by means of two opposed rams at Station No. 5. Both these rams are cam operated and are provided with two holes in alignment with the bearing pins and in these holes are adjustable plugs which are set so that their faces are slightly set back from the faces of the rams by a distance equal to the amount by which the ends of the bearing pins are to project beyond the outer faces of the link plates. The working faces of these rams are adjustable and are so adjusted that the opposed faces of the rams approach one another to a distance equal to the desired final width between the outer faces of the upper link plates and these rams, thereby ensuring that the clearance between the outer and inner link plates shall be uniform throughout the chain.

A device is provided which automatically omits one outer link plate at predetermined intervals. This device may be provided either at Station No. 3 or Station No. 4. It consists of a spring retracted plunger the end of which is arranged opposite the horizontal exit from the link plate magazine, so that when the plunger is pushed forward it enters the

magazine and pushes back the stack of link plates within it, thereby preventing the supply of one of the link plates. This pushing forward of the plunger is effected by a cam carried by an endless chain hanging in a loop over a sprocket wheel geared to the operating mechanism of the machine so as to rotate intermittently. A lever having a cam roller is interposed between the plunger and the chain cam so that every time the cam engages the cam roller the end of the lever pushes forward the plunger to prevent the delivery of one link plate.

At that one of the two Stations Nos. 3 and 4 which is not provided with this device there is a hand-operated plunger arranged in the same position as the automatically operated plunger just described and provided with a catch so that it can be pushed into the end of the link plate magazine and left there so as to interrupt the supply of link plates. A hand-operated catch is also provided on the automatically operated plunger so that this plunger also can be held in the feed-interrupting position. Similar arrangements may be provided for interrupting the supply of inner links and bearing pins, the purpose of these provisions being to enable the machine to be run idly for the purpose of adjustment or setting without the necessity of emptying the hoppers and magazines.

The drive to the camshaft is through a dog clutch which is provided with an automatic disengaging mechanism, so arranged to function through the failure to feed a component, the misfeeding of a component, or the feeding of a faulty component. This mechanism consists of a cam operated bell-crank lever having an inclined cam portion working in conjunction with an inclined cam projection on the sliding clutch member. The lever is oscillated so that its cam portion moves in and out of the path of the cam projection on the clutch member, and is so arranged that when it is detained in that path (by a bar to be described later) the sliding clutch member will be forced out of engagement, thus stopping the machine. The cam operating the bell-crank lever positively moves the lever-cam portion into the path of the clutch member cam projection, and a coil spring attached to the lever withdraws it from this zone to allow the projection on the clutch member to pass, whereby the clutch is not disengaged and the machine runs continuously.

A bar arranged parallel to the cam shaft is reciprocated, in synchronism with the rotation of the cam shaft, in one direction positively and in the other direc-

tion by means of a spring, and this bar cooperates with a projection on the clutch-disengaging lever so that if the bar is detained at the end of its positive movement and thereby prevented from moving back under the influence of its spring the projection on the lever will abut against the side of the bar near one end thereof and will thereby be prevented from moving out of the path of the cam projection on the clutch member, thereby causing the clutch to be disengaged. If, however, the bar is not detained its ends will have been withdrawn clear of the projection on the lever at the time that the cam projection is about to engage with the cam portion of the lever, so that the spring attached to this lever can withdraw it out of the path of the cam projection so that the clutch is not disengaged.

The bar is provided with a number of notches with each of which is associated a latch. Each latch is operatively connected to a feeler which is reciprocated into and out of engagement with a separate one of the components at its respective assembly position, the movement into engagement with the component being effected by means of a spring. The parts are so timed in relation to one another that if a correct component is correctly fed at any station the feeler cooperating with that component will cause the corresponding latch to pass into and out of the associated notch in the bar while that bar is stationary at the end of its positive movement, so that the bar is free to be retracted by its spring. If, however, a component is missing or is incorrectly fed the abnormal movement of the feeler will cause the latch to remain in the notch thereby preventing the retraction of the bar, which is thus detained so as to prevent the retraction of the clutch-disengaging lever as described above. Thus, any misfeeding of any component, or the absence of a component will cause the clutch to be disengaged.

The feeler for the inner links consists of two spring-loaded plungers which are arranged to come down upon the two rollers of the inner link, and these plungers are carried by the feed rack, the forward movement of which is effected by a spring while its rearward movement is brought about positively. A fixed stop is arranged so that the plungers will clear it if they are resting on the rollers of an inner link, but should the inner link be missing, or even should a roller be missing from the link, one or other of the plungers will abut against the fixed stop and will prevent the forward movement of the feed rack. The latch associated

with the inner links is connected directly to the feed rack and therefore indirectly to the plungers which constitute the feelers proper. The feed rack may be provided with similar spring-pressed plungers which are brought down on to the bearing pins and which abut against a fixed stop if a bearing pin is missing. Thus, a single latch connected to the feed rack serves both for inner links and for bearing pins.

Separate latches are provided for the feelers engaging the two outer link plates

on opposite sides. Each of these feelers engages directly with the upper edge of the outer link plate and is directly connected to this latch. If the link plate is missing the feeler will proceed further than normal and will cause the latch to detain the bar.

Dated the 28th day of November, 1931.

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COMPLETE SPECIFICATION.

Improvements relating to Machines for the Production of Transmission Chains.

We, THE RENOLD AND COVENTRY CHAIN COMPANY LIMITED, a Company organised under the laws of Great Britain, JAMES HENRY ICKE, a British Subject, and CLARENCE JAMES PORTS, a British Subject, all of Spon End Works, Coventry, Warwickshire, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to machines for assembling the components of a jointed link chain, of the kind in which components during assembly are located with the axes of all the joints lying in a horizontal plane—that is to say, the length of the chain is horizontal and the outer side plates are vertically on edge.

The object of the present invention is to provide a machine of this kind for assembling jointed link chains of the roller type the components of which consist of inner link combinations already assembled, jointing studs, and outer side plates.

According to one feature of the present invention inner link combinations are fed to an intermittently moved locating means which locates them in correct spaced relationship with the axes of all their bushes in a horizontal plane and moves them step-by-step; jointing studs are inserted into the bushes and subsequently outer side plates are placed in positions at the sides of the succession of inner link combinations and forced on to the jointing studs already within the bushes of the inner link combinations by pressure applied laterally to the outer side plates.

According to a further feature of the invention the locating means comprises a horizontally-disposed feed rack having its teeth directed downwardly and sur-

mounting a smooth horizontal guideway upon which the inner link combinations rest, means being provided for moving the rack in a cyclical path comprising a forward movement along the horizontal guideway with its teeth in proximity to the guideway, an upward movement, a return horizontal movement in the raised position, and a downward movement to bring its teeth once more into proximity to the guideway at the beginning of its forward horizontal movement. The pitch of the rack teeth is equal to the pitch of the chain to be assembled, and it will be appreciated that inner link combinations placed on the guideway one at a time at the rear end of the feed rack will be engaged by the rack teeth, fed forward along it during the forward movement of the feed rack, left stationary upon the guideway during the upward and return movements of the rack and re-engaged by different teeth of the feed rack, and fed forward again during the ensuing forward movement. The amplitude of the horizontal movement of the feed rack is equal to two chain pitches whereby a succession of inner link combinations are spaced apart along the guideway with the axes of their adjacent bushes separated by a distance equal to the pitch of the chain, all the combinations in the succession being fed forward a distance equal to two chain pitches during each forward movement of the rack.

A further feature of the invention consists in improved means for locating the ends of the jointing studs during the process of forcing an outer side plate over them, which consists in locating pins having pointed ends which are mounted resiliently in the ram which applies the pressure to the outer side plate and which are of a diameter to fit the holes in these

plates, the pointed ends entering correspondingly-shaped recesses centrally disposed in the end faces of the jointing studs. When the ram advances the locating pins first pass through the holes in the outer side plates and locate these plates correctly, and their pointed ends then enter the recesses in the ends of the jointing studs and bring these pins into register with the holes. Further movement of the ram causes the locating pins to retreat into the ram against spring pressure, and finally the ram forces the side plates over the ends of the jointing studs.

The machine may comprise a pair of rams arranged to apply pressure from both sides to each inner link combination in turn whereby they are all brought to a definite width prior to the assembly therewith of the outer side plates. In the preferred design this is accomplished by employing one moving ram and a fixed anvil.

The machine may be arranged to press each pair of outer side plates on to the jointing studs simultaneously, there being two rams opposite to one another for this purpose, each preferably provided with pointed locating pins such as are referred to above. It is preferred, however, to apply the outer side plates in more than one stage, those on one side being applied at one station, and those on the other side being applied at a subsequent station. In this case two further rams oppositely disposed are provided which finally complete the pressing on of each pair of outer side plates and bring them all to a uniform separation.

A machine embodying the invention will now be described by way of example with reference to the accompanying drawings, in which

Figure 1 is a diagram in plan showing the various operations performed by the machine, Figures 2 to 5 are detail views showing successive stages in the feeding of the inner links,

Figure 6 is an elevation of the machine as seen from the side remote from the cam shaft,

Figure 7 is a plan of the complete machine,

Figures 8 to 12 are end elevations in section at the positions A, B, C, D and E respectively, viewed from the left of Figures 6 and 7,

Figure 13 is an end elevation of the machine also looking from the left of Figures 6 and 7.

Figure 14 is a detail view of the mechanism for actuating the feed rack, as seen from the cam shaft side of the machine, parts being broken away for clearness,

Figure 15 is a view similar to Figure 14 showing the parts omitted from that figure,

Figure 16 is a plan in section on the line XVI—XVI in Figure 14,

Figure 17 is a detail view in section on the line XVII—XVII in Figure 15,

Figure 18 is a diagram illustrating the path of movement of the feed rack,

Figures 19 to 22 are sectional elevations on an enlarged scale of parts of Figures 9 to 12 respectively,

Figure 23 is a side elevation showing mechanism at station B,

Figure 24 is a side elevation of the feed rack showing certain feelers which co-operate with a stop mechanism,

Figure 25 is a cross sectional elevation of the machine taken on the line XXV—XXV in Figure 7 with parts broken away,

Figure 26 is a plan of Figure 25,

Figure 27 is a side elevation of Figure 25 as seen from the left,

Figure 28 is a side elevation of the machine as seen from the left in Figures 8 to 12 but with the cam shaft omitted,

Figure 29 is a side elevation of part of the mechanism for feeding the inner links.

Referring first to Figures 1 to 5, which show the successive operations performed by the machine, the assembly of the chain takes place on a horizontal guideway 20 having a central rib 22 on which the rollers of the chain rest. There are five assembly stations placed along the guideway and designated respectively A, B, C, D and E. Before describing the operations performed at these stations it will be explained how the inner links are fed along the guideway. The inner links are fed one at a time on to the guideway 20 at the extreme left thereof as seen in Figures 2 to 5—that is at the upper end as seen in Figure 1, which is a plan. As each link 24 takes its place upon the guideway a feed rack 26, having its teeth 28 directed downwardly, is brought down upon the link as indicated in Figure 2. The pitch of the teeth 28 is the same as that of the chain to be assembled, and the rack extends forwardly along the guideway to a point in advance of station C. After its downward movement the rack moves forwardly (to the right) into the position shown in Figure 3, the extent of this movement being equal to two chain pitches. The next inner link is then gravity fed upon the guideway and the rack is raised so that its teeth are clear of the links, as shown in Figure 4. Thereupon the rack moves back to its original position (Figure 5) and descends

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once more into the position shown in Figure 2. It will be readily appreciated that if this cycle of operations is repeated the result will be to feed forward along the guideway a succession of inner links in correct spaced relation with one another, the succession of links halting after each feed movement.

As each inner link reaches station A (Figure 1) a ram 30 approaches it from one side and presses the link against a fixed anvil 32 on the other side, the faces of the ram and of the anvil approaching one another by a distance equal to the finished width of the inner links. The object of this operation is to ensure that links which are too wide, and which would therefore cause tight joints, are reduced to the proper width, and to flatten out any burrs which might be present.

At station B jointing studs 34 are fed in pairs in a manner which will be described hereinafter, each pair of studs being presented in a horizontal position at the correct distance apart as shown. A ram 36 is provided with two plungers 38 which slide within the ram under spring pressure. At the opposite side of the guideway there is another ram 40 also provided with plungers 42 sliding within the ram against spring pressure. These two rams are moved, in a manner which will be described later, in such a way that the plungers 42, which will be referred to as the guiding plungers, first pass through the bushes of the inner link, the ram 36 being in the retracted position as shown. The ram 36 begins its forward movement while the guiding plungers 42 are still within the bushes, causing the plungers 38, hereinafter referred to as the inserting plungers, to push the studs 34 to the left until their ends come into contact with the ends of the guiding plungers. Thereupon the ram 40 is retracted at the same speed as the continued leftward movement of the ram 36, until the studs are completely within the bushes. The two rams then separate leaving the studs within the bushes. The function of the guiding plungers 42 is to ensure that the bushes of the inner link shall be correctly located to receive the studs, and to guide the latter into the bushes.

At station C outer side plates 44 are fed one at a time to one side of the guideway so that each side plate stands on edge with the line joining its holes horizontal and in a position to span the gap between two adjacent inner links, with its holes opposite the two bushes. On the opposite side of the guideway is a fixed anvil 46, and on the same side is a ram 48 the object of which is to force

the side plate 44 over the ends of the studs 34, these studs being supported upon the anvil 46. The ram 48 has sliding within it two centering plungers 50 which are held extended by springs in the same way as the plungers 38 and 42. The free ends of these plungers are in the form of obtuse-angled conical points, seen more clearly in Figure 20, which as the ram advances enter corresponding countersinks or recesses in the ends of the studs. The plungers are a close fit in the holes in the side plate through which they pass, and it will be seen that after the points of the plungers have engaged the countersinks in the studs the holes in the side plate will be accurately centred with respect to the studs, so that when the ram 48 presses the side plate inward (the plungers 50 meanwhile retreating within the ram) the holes in the side plate will slide easily over the ends of the studs.

At station D there is a similar anvil 52, ram 54 and centering plungers 56 which are arranged oppositely with respect to those at station C and which press the side plates 58 on the other side of the chain on to the ends of the studs 34. From this point the chain is fully assembled but it is subjected to a final operation at station E, which consists in applying to opposite sides of it two rams 60. The movements of the rams 48 and 54 are such that the side plates are not pressed to their final positions over the studs, and the purpose of the rams 60 is to complete the pressing operation, the working faces of these rams being so adjusted that they approach one another to a distance equal to the desired final width between the outer faces of the outer side plates. Thus it is ensured that the clearance between the outer and inner side plates shall be uniform throughout the chain. The faces of the rams 60 are provided with holes to clear the ends of the studs which project slightly from the side plates, and in these holes are adjustable plugs which will be described later, the ends of which are set back slightly from the faces of the rams by a distance equal to the amount by which the ends of the studs are to project beyond the outer faces of the side plates.

The feed rack 26 and the rams 30, 36, 48, 54 and 60 are driven by cams on a cam shaft 62 which extends from end to end of the machine on one side as shown in Figures 6 to 13, this cam shaft being driven by a suitable motor (not shown) through a dog clutch 64.

Referring to Figures 13 to 18, the feed rack 26 is fixed to a slide 66 which slides horizontally in guideways 68 in a bracket

70, which is in the shape of an inverted letter L and the vertical part of which has a slide 72 sliding in vertical guideways 74 fixed to the frame of the machine. 5 The slide 66 has a vertical slot 73 in which slides a shoe 75 carried by a pin 76 which extends through a horizontal slot 78 in the horizontal part of the bracket 70 and is fixed to an arm 82 10 carried by a horizontal transverse spindle 84. This spindle also carries an arm 86 connected by a link 88 to a pivoted arm 90 on which is mounted a cam follower roller 92. A cam 94 on the cam shaft 62 15 co-operates with the cam follower as shown in Figure 13, and as will be clear this cam will cause the slide 66 and with it the feed rack 26 to reciprocate in a horizontal direction. The lower end of 20 the bracket 70 is connected by a pin and slide to one end of the pivoted lever 96, the opposite end of which carries a cam follower roller 98 which is engaged by a cam 100 carried by the cam shaft 62, 25 which causes the bracket 70 to be reciprocated vertically. The cams are so arranged as to cause rapid movements separated by delays of considerable duration, and the setting of the cams is such 30 as to cause the slide to describe a rectangular path shown in Figure 18 which, as will be seen, is the same as the path described with reference to Figures 2 to 5, as seen from the opposite side.

35 Station A is illustrated in Figure 8 which, in common with Figures 9 to 12, is a cross section seen from the left of Figures 6 and 7, that is to say, looking downwards in Figure 1. This figure 20 shows the fixed anvil 32 and the sliding ram 30 which is connected by a link 102 to the upper end of the pivoted lever 104 carrying a cam follower roller 106 engaged by a cam 108 on the cam shaft 25 62, this cam being so timed as to move the ram 30 into engagement with the inner link during a dwell in the movement of the inner links along the guideway 20.

50 At station B (Figures 9 and 19) studs are fed from a hopper, not shown, through two separate tubes 110 placed side by side. From these tubes the studs enter holes in a stud magazine 112 (Figure 23). This 55 magazine is in the form of a disc, the thickness of which is the same as the length of the studs. It is mounted on a spindle 114 between plates 116, which fit it closely at the sides. In this disc is a 60 series of pairs of stud-carrying holes 117, the holes of each pair lying along a radius. The edge of the plate is formed with ratchet teeth 118, and a pawl 120 pivoted to the feed rack slide 66 co-65 operates with these ratchet teeth to turn

the disc through an angle equal to the angle between successive pairs of holes during the latter part of each forward stroke of the feed rack. A spring pressed pin 122 co-operating with countersunk holes 124 in the disc ensures that the disc shall not overthrow—that is to say it ensures that the disc will come to rest in an exact position. It will be seen that every time a pair of holes comes opposite the outlet from the tubes 110, a pair of studs will enter the holes. If any stud is too long the excess length will project beyond the side of the disc and the projecting end will remain in the feed tube thereby preventing the disc from rotating and also preventing the feed rack from moving to its full extent. The same thing will happen if a stud is too short, because the stud which follows it will then project beyond the end of the feed tube into the hole in the disc. As will be explained hereinafter any interference with the free movement of this feed rack causes the machine to stop.

At a position diametrically opposite to the outlets from the tubes 110 the studs are brought opposite the plungers 38, 42, which are clearly shown in Figure 19, which also shows the springs 37^a, 41 which maintain the plungers extended to allow them to recede into the rams 36, 40. The operation of these plungers has already been described, and it is therefore unnecessary to repeat the description. 100 The ram 36 is connected by means of a link 126 to a pivoted arm 128 carrying a cam follower roller 130 actuated by a cam 132 on the shaft 62. The ram 40 is operated in a similar way through a link 134, a pivoted arm 136, a link 138 extending across the machine, an arm 140, a cam follower 142 and a cam 144, the two rams 132 and 144 being so shaped as to bring about the movements described during a dwell in the feed movement of the inner links.

Station C is shown in Figures 10 and 20. At this station the outer side plates are stacked in the magazine 146 from 115 which they are fed by gravity through a curved guide 148 to a recess or rebate 149 in the face of a vertical feed slide 150 at the lower end thereof. This feed slide is reciprocated by means of a pivoted lever 152, a link 154, an arm 156 carrying a cam follower 158 and a cam 160 all as shown clearly in Figure 10. At each stroke of the feed slide a side plate is delivered on to the guideway 20 in a 120 position already described with reference to Figure 1, and it is centred by the plungers 50 and forced over the ends of the studs by the ram 48 as previously 125 described. The ram is connected by 130

means of a link 162 to a pivoted arm 164 actuated by means of a link 166 from an arm 168 on which is a cam follower 170 actuated by a cam 172.

5 At station D, Figures 11 and 21, the arrangements are very similar, the magazine for the stack of side plates being represented at 174 and the vertical feed slide at 176. The arrangements for 10 reciprocating this feed slide are not shown in these figures; they are identical with those described with reference to Figure 10. The ram 54 already described with reference to Figure 1 is connected by a 15 link 178 to a lever 180 carrying a cam follower roller 182 actuated by a cam 184.

At this station there is a device for causing a side plate to be omitted at predetermined intervals. This device consists of an endless chain 186 carrying a cam block 188 and looped around a sprocket wheel 190. This sprocket wheel is rotated step by step by means of a ratchet and pawl mechanism actuated by 25 a cam 192 acting through an arm 194 and a link 196. A spring-retracted plunger 198 is arranged with one of its ends opposite the exit from the side-plate magazine and its other end lies against 30 a lever 200 carrying a cam follower 202 in the path of the cam block 188. When this cam block engages the cam follower 202 the lever 200 will be rocked towards the left thereby pushing the plunger 198 35 towards the left and causing its end to push the stack of side plates back into the magazine. This pushing back of the side plates lasts only for one stroke of the slide 176 with the result that whenever 40 the cam block 188 comes round a side plate will be omitted. Thus instead of making a continuous length of chain the machine will assemble chain in predetermined lengths. At station C a hand-operated plunger 204 is provided so that 45 the feed of side plates at that station can be interrupted when desired. The slide 176 is slotted to receive the plunger 198 and the upper end of the slot is so located 50 that it co-operates with the plunger to prevent the slide 176 from moving down further than it would do if its lower end were supported on a side plate. The reason for this will be explained hereinafter.

Referring now to Figures 12 and 22 (station E) the left hand ram 60 is connected by a link 206 to a pivoted arm 208 carrying a cam follower 210 actuated by a cam 212 on the shaft 62. The right hand ram 60 is actuated by another cam 214 by means of a cam follower 216, an arm 218, a link 220, an arm 222 and a link 224.

65 Reference has already been made to

the fact that the rams 60 are provided with holes which register with the ends of the jointing studs. Referring to Figure 22, these holes are occupied by plugs 201 and are provided with adjusting screws 203 engaging with screw-threaded bores 205 in the rams. The screw-thread enables the plugs to be adjusted so that their ends are set back a distance equal to the amount by which the ends of the studs are to project beyond the outer faces of the link plates. This ensures that the amount of this projection shall be equal on both sides of the chain.

The rams 60 are formed with forward extensions 61 which meet together above the chain when the rams make their closest approach. These extensions provide a positive safeguard against too small a distance between the outer side plates. The rams 60 are carried by slides 63 within which they are adjustable longitudinally, this adjustment being effected by means of nuts 65.

The inner links are fed to the rear end of the guideway 20 by gravity through a tubular chute 21, Figure 29, from a suitable hopper, not shown. This hopper may be similar to that shown in Figure 12 of British patent specification No. 295,439. As the inner links are not constrained or held in any way on the guideway when the rack 26 is raised, it is necessary to prevent them from being pushed forward by the weight of the links in the chute 21 during the pauses in the feeding movement. This is effected by a detent 23, Figure 29, which is guided vertically and moves in a notch 25 in the guideway. A roller 27 journaled on the detent is engaged by a horizontal slot 29 in a plate 31 fixed to the side of the rack 26, the arrangement being such that when the rack is in its lower position the top of the detent is flush with the surface of the guideway, while when the rack is raised the detent is raised into a position just in front of the first inner link on the guideway. Thus this link cannot move forward until the rack is in its lower position. If desired the detent may be urged upwards by a spring, in which case the slot 29 would be dispensed with, the lower edge 100 of the plate 31 serving to depress the detent.

The finished chain is fed from the machine by means of a sprocket wheel 33 which is rotated intermittently by means 105 of a pawl 35 and a ratchet 37, the pawl being carried on an arm 39 rocked by means of a cam 41, an arm 43 (see Figure 7) and a link 45.

The rams 30, 36, 40, 48, 54 and 60 are 110

positively moved in the operative direction and are retracted by means of springs, which are clearly shown in Figures 8 and 12. The two vertical feed slides 150, 176 and the feed rack 26 are, however, actuated in the feeding direction by spring action and are retracted positively. Thus in Figure 10 it will be seen that the spring 153 moves the slide 150 downwards, and a similar spring is used for the slide 176, while as seen in Figure 13 the spring 71 moves the slide 70 downwards and the spring 89 moves the feed rack forwards. The object of this in the case of the feed rack is to enable this forward feed movement to be arrested and in the case of the slides 150, 176 to enable these slides to move further than the normal, in both cases for the purpose of actuating a stop mechanism to throw out the clutch 64 if certain failures in the feed operations occur, or if incorrect components are fed. It has already been mentioned that the feeding of a stud which is too long will cause the feed rack to be arrested before it reaches the end of its forward stroke, and the feed rack is also caused to be arrested in case of errors in the feeding of the inner links and of the studs, as will now be described with reference to Figure 24.

Two feelers 226 are arranged to slide vertically in guides at the side of the feed rack. These feelers are urged downwardly by means of springs 228, and their lower ends abut against the rollers of each inner link as the rack descends to the position shown in Figure 2. The feelers extend sideways to the left as seen in Figure 1 to such an extent that the anvil 32 is in their track. If, however, they are supported on the rollers of an inner link the feelers will pass over the top of the anvil and the movement of the rack 26 will not be impeded. If, however, there is no inner link present or even if a roller is missing from a link, one or both of the feelers will descend further than the normal and one or other of them will encounter the side of the anvil 32 thereby stopping the forward feed movement of the rack 26. Two feelers 230, similar to those already described, are urged downwards by means of springs 232 into engagement with the studs 34 at station B. The lower ends of these feelers are provided with V notches so that when they are supported by the studs 34 their lower faces are at about the level 60 of the axes of the studs as clearly shown. When thus supported they are able to pass over a ledge 234 (see also Figure 19) and thus the rack 26 is not impeded. If, however, a stud is missing or if either of them is too small in diameter, one or

other of the plungers 230 will encounter the end of the ledge 234 thereby stopping the forward movement of the feed rack 26. The level of the upper surface at 235, Figures 19 and 24, is such that it acts as an abutment to prevent over-feeding of the studs 34. It is therefore necessary to make flat the underneath side of the pins 42 to clear this abutment.

Referring now to Figures 25 to 28, the sliding member 236 of the clutch 64 (Figure 7) through which the cam shaft 62 is driven, is provided with a projection 238 the forward face of which is inclined in the circumferential direction as seen most clearly in Figure 27, and it will be seen that if a stationary stop is placed in the path of the projection 238 where it will be encountered by the inclined face on the projection, the result of the encounter will be that the clutch member 236 will be moved to the right as seen in Figure 27 thereby disengaging the clutch and stopping the machine. A bar 240 seen also in Figures 8 to 12 slides horizontally in guides lengthwise of the machine. A lateral projection from this bar carries a cam follower roller 242 engaged by a face cam 244 on the cam shaft 62. For the most part the face of the cam 244 is flat, but it is provided with a recess 246 which enables the bar to move to the left as seen in Figure 7 under the influence of a spring, not shown. The cam shaft 62 carries an edge cam 248 adjacent the clutch 64, and this cam operates with a pivoted lever 250 which, as seen in Figure 25, is formed with a stop 252 having an inclined face, which stop, when the lever is rocked in an anti-clockwise direction as seen in Figure 25, is in the path of the projection 238. The lever is urged in a clockwise direction by a spring 254 and the cam 248 has a portion of small radius 256 which allows the lever to swing clockwise under the influence of the spring, thus withdrawing the stop 252 from the path of the projection 238. So long as this action is allowed to take place at each rotation of the cam shaft, the clutch will remain in engagement, but if the lever 250 is prevented from rocking clockwise, whereby the stop 252 remains in the path of the projection 238, then the encounter so as to declutch the machine.

A tailpiece 258 on the lever 250 operates with the extremity of the bar 240. The reciprocatory movement of this bar is so timed that whereas its extremity is opposite the tailpiece during the greater part of the rotation of the cam shaft as indicated at X in Figure 26, this ex-

tremity is withdrawn to a position clear of the tailpiece, as indicated at Y, during the period when the part 256 of the cam permits clockwise swinging of the lever 250. It will be clear therefore that if the bar 240 is detained in the position X during this latter period, the stop 252 will be maintained in the path of the projection 238 thus causing de-clutching. It will also be appreciated that the bar 240 can be detained in the position X because its movement from X to Y is caused by a spring.

The retention of the bar 240 in the position X occurs when the feed rack 26 is prevented from completing its forward movement through any of the causes previously described, or when either of the feed slides 150, 176 performs an excessive downward movement in consequence of the absence of a side plate at station C or station D. Referring to Figures 13, 15 and 28 a latch 260 is pivoted about an axis lying lengthwise of the machine and is urged in the anticlockwise direction by a spring 262, and in the opposite direction by means of a short extension 264 of the arm 86, this extension abutting against the tailpiece 266 on the latch 260. The bar 240 is provided with a notch 268, Figure 28, through which the lower end of the latch 260 passes, and the timing of the latch in relation to that of the bar is such that if the arm 86 performs its normal movements the end of the latch is clear of the notch 268 when movement of the bar from the position X to Y is permitted by the cam recess 246; while if the arm 86 fails to make its complete movement in consequence of the arresting of the feed rack 26 in its forward movement, the lower end of the latch 260 will be within the notch 268 when the bar is otherwise free to move from X to Y. Hence the bar will be detained in the position X and declutching will occur.

Referring now to Figures 10 and 28, a latch 270 is pivoted similarly to the latch 260, its lower end swinging through a notch 272 in the bar 240. The spring 274 tends to rotate the latch clockwise while an extension 276 of the lever 152 tends to swing the latch in the opposite direction during the downward movement of the slide 150. The lower end of the latch is provided with a notch 278 which, when the lower end of the feed slide 150 is supported on the edge of a side plate which has been fed to the assembly position, straddles the bar 240 as shown in Figure 10. The timing of the various cams is such that the cam permits the bar to move from X to Y while the latch is in the position shown. It will be clear that if there is no side plate beneath the

lower end of the slide 150 the spring 153 will cause the lever 152 to move further, thereby causing the extension 276 to move the lower end of the latch 270 further to the right, as seen in Figure 10, thereby bringing a part of the latch into the notch 272. Thus the bar 240 under these conditions is unable to move from X to Y and de-clutching will occur. An exactly similar latch 280 is provided for the feed slide 176 at station D, this latch co-operating with a notch 282 in the bar in precisely the same manner as described in connection with the latch 270.

As previously explained, when the feeding of side plates is interrupted momentarily by the plunger 198, the feed slide 176 is prevented from moving downwards beyond the normal, with the result that the latch 280 performs its normal movement and the machine is not de-clutched.

There are certain details of the machine shown in the drawings which are not essential to its operation and need not therefore be described in detail. Thus in Figure 6 there is shown a brake 286 by means of which the cam shaft 62 may be brought to rest quickly when the clutch 64 is thrown out, while a hand-wheel 288 is provided which can be placed in gear with the cam shaft to enable the machine to be turned slowly by hand for the purpose of setting the rams and other tools.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A machine of the kind referred to for assembling the components of a jointed link chain of the roller type, comprising in combination an intermittently moved locating means to which inner links are fed and which locates them in correct spaced relationship with the axes of all their bushes in a horizontal plane and moves them step-by-step, means for inserting jointing studs into the bushes of the inner links at one station, means at a later station for placing outer side plates in position at the sides of the succession of inner links, and means for thereafter assembling said outer side plates with the jointing studs within the bushes.

A machine according to Claim 1, wherein the inner links rest upon a smooth horizontal guideway and wherein the locating means comprises a horizontally disposed rack surmounting the guideway, the teeth of which have a pitch equal to the pitch of the chain to be assembled and are directed downwardly, means being provided for moving the rack in a cyclical

path comprising a forward movement along the horizontal guideway with its teeth in proximity to the guideway through a distance equal to two chain 5 pitches, an upward movement, a return horizontal movement in the raised position, and a downward movement to bring its teeth again into proximity to the guideway.

10. 3. A machine according to Claim 1 or Claim 2 wherein jointing studs are inserted two at a time into the adjacent bushes of two inner links by means of a pair of inserting plungers such for 15 example as 38.

4. A machine according to Claim 3 wherein a pair of guiding plungers such for example as 42 are provided, which are caused to enter the bushes from the side 20 remote from the inserting plungers prior to the inserting movement and are retracted during the inserting movement.

5. A machine according to any preceding claim, wherein the forcing of the side 25 plates on to the jointing studs is effected by means of a ram such for example as 48 provided with a pair of spring-pressed centering plungers such for example as 50, the free ends of which are in the form 30 obtuse-angled conical points and which, when the ram advances, extend through the holes in the side plates, engage countersinks or recesses in the ends of the studs thereby centering them with 35 respect to the holes in the side plates, and thereupon retire within the ram during the pressing operation.

6. A machine according to any preceding claim, wherein the outer side plates 40 on opposite sides of the chain are pressed on to the studs at positions spaced apart along the length of the chain.

7. A machine according to any preceding claim wherein each inner link is subjected, prior to the insertion of jointing 45 studs, to a pressing operation for example by means of a ram such as 30 co-operating with an anvil such as 32 for the purpose described.

50. 8. A machine according to any preceding claim wherein the outer side plates on opposite sides of the chain are subjected to a final pressing operation for example by means of two rams such as 60 for the 55 purpose described.

9. A machine according to any one of claims 2 to 8, wherein the feed rack is provided with feelers (for example 226) engaging the rollers of the inner links and co-operating with a stop (for 60 example 32) whereby the feed movement of the feed rack is interrupted if either of the feelers descends beyond its normal roller-supported position, for the purpose described. 65

10. A machine according to any one of claims 2 to 9, wherein the feed rack is provided with feelers (for example 232) engaging the pair of jointing studs and co-operating with a stop (for example 234) whereby the feed movement of the feed rack is interrupted if either of the feelers descends beyond its normal stud-supported position, for the purpose described. 70

11. A machine according to any preceding claim, wherein the pairs of jointing studs are fed into holes in a movable stud-magazine (for example a rotatable disc such as 112) which is moved to transfer each pair of studs to the inserting position. 75

12. A machine according to Claim 11 wherein the stud-magazine is moved as aforesaid by the feed slide and is of a width equal to the length of the jointing studs, whereby if studs of incorrect length are fed to the holes therein it cannot be moved whereby the movement of the feed slide is interrupted, for the purpose described. 80

13. A machine according to Claim 8 wherein the faces of the two rams are provided with recesses for the reception of the ends of the studs of such a depth as to ensure that the studs shall project from the side plates to equal extents on both sides of the chain. 85

14. The machine for assembling jointed link chains substantially as described with reference to the accompanying drawings. 95

Dated this 26th day of September, 1932.

For the Applicants:
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 Chartered Patent Agents,
 51/52, Chancery Lane, London, W.C. 2.

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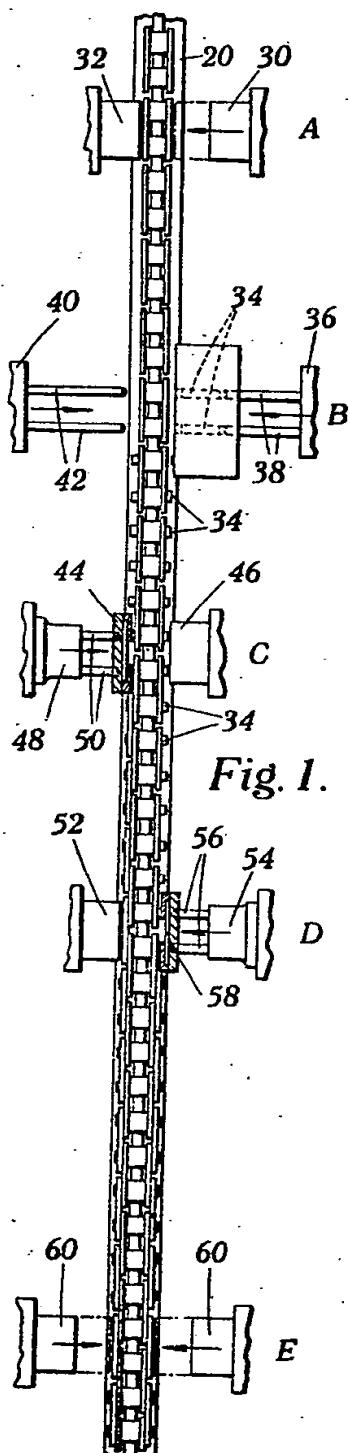


Fig. 1.

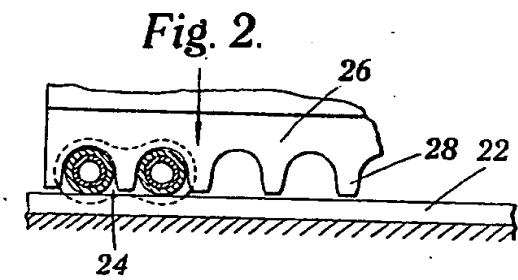


Fig. 2.

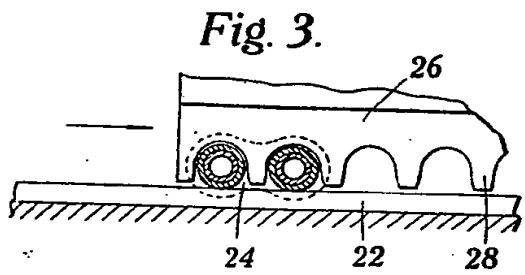


Fig. 3.

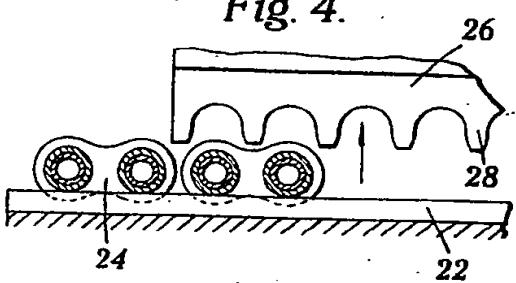


Fig. 4.

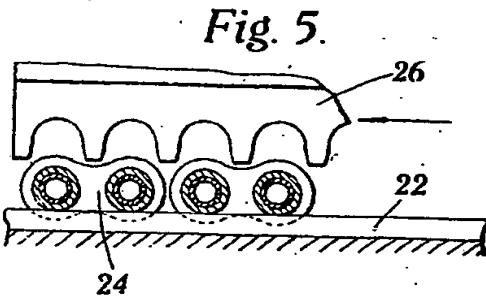
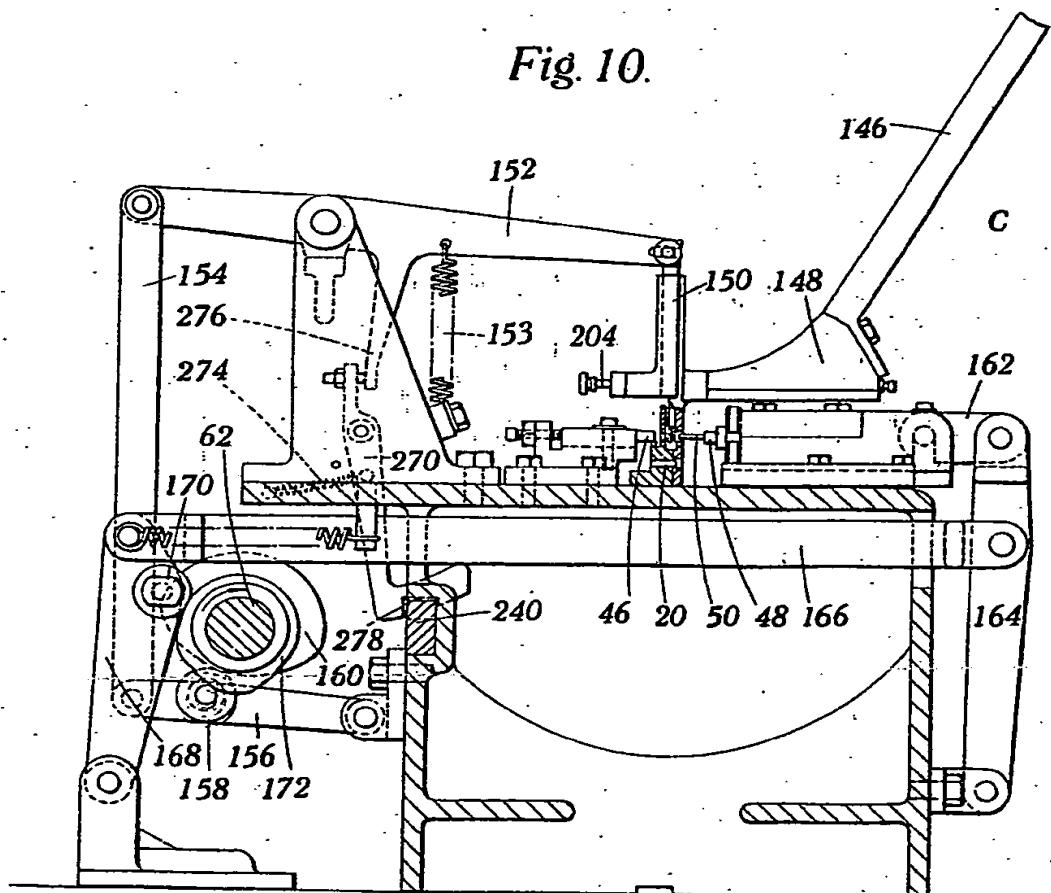


Fig. 5.

Fig. 10.



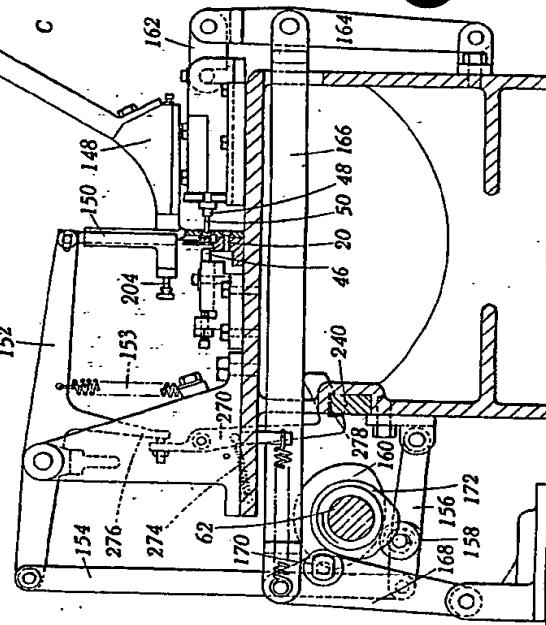
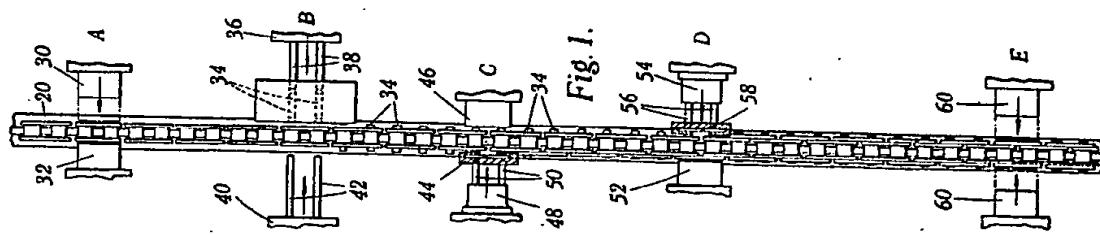


Fig. 10.

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Fig. 6.

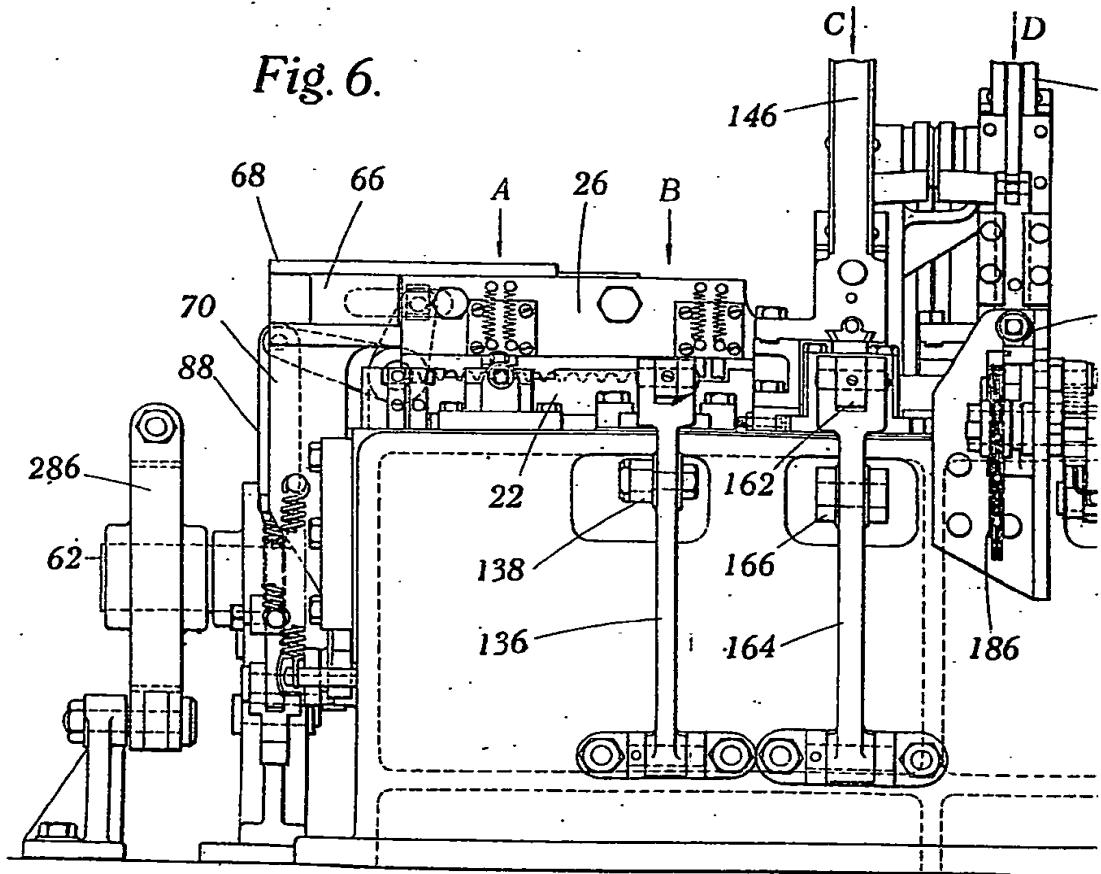
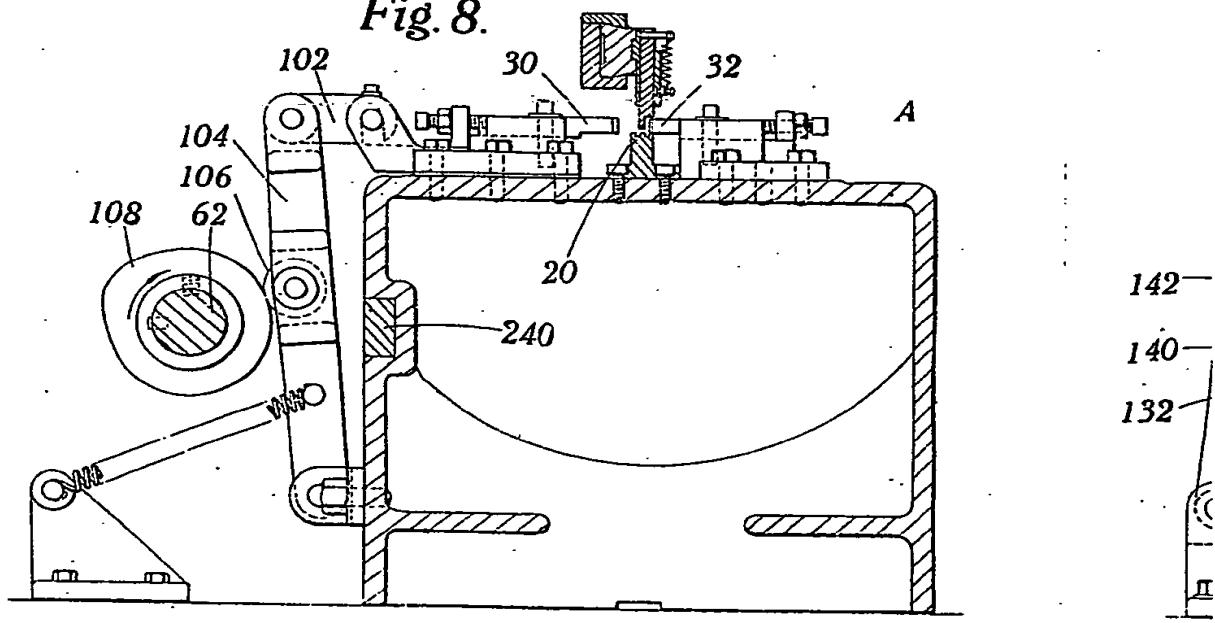


Fig. 8.



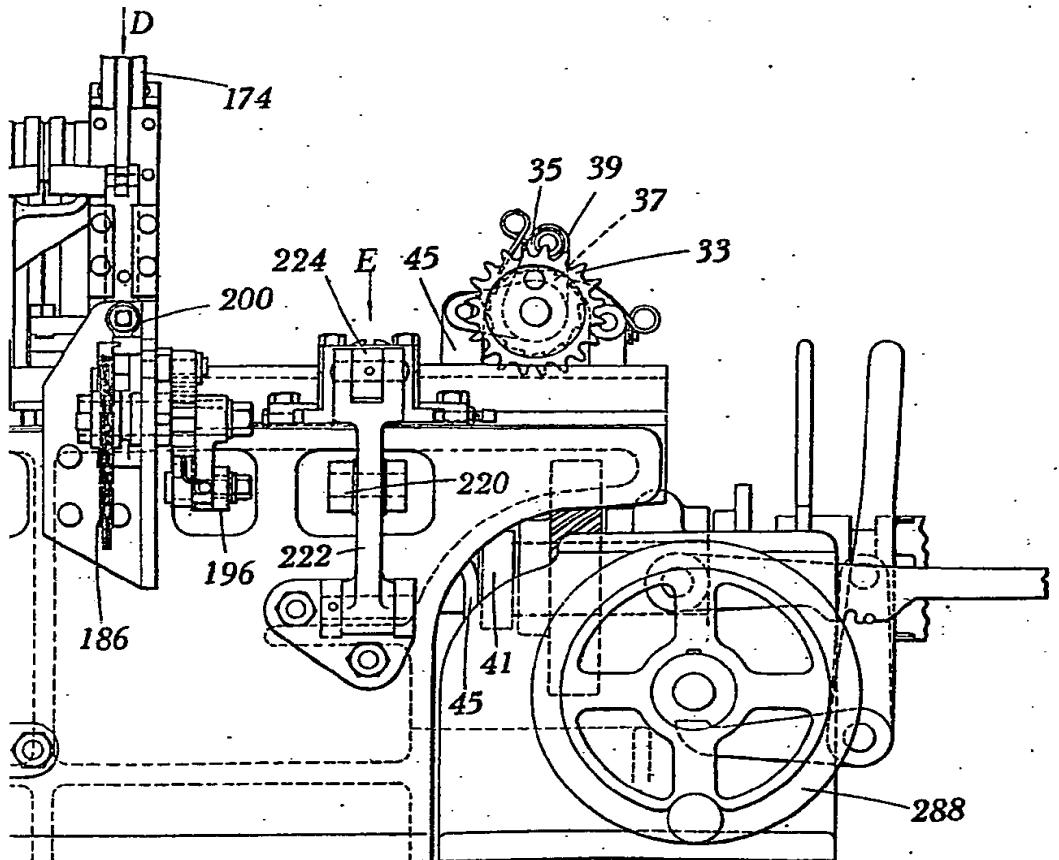
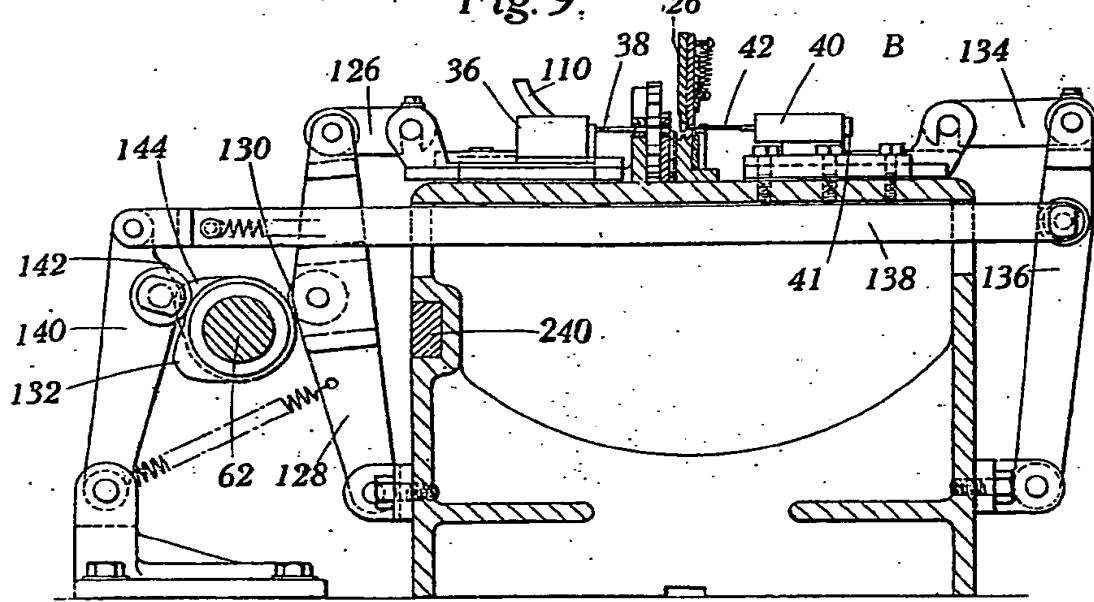


Fig. 9.



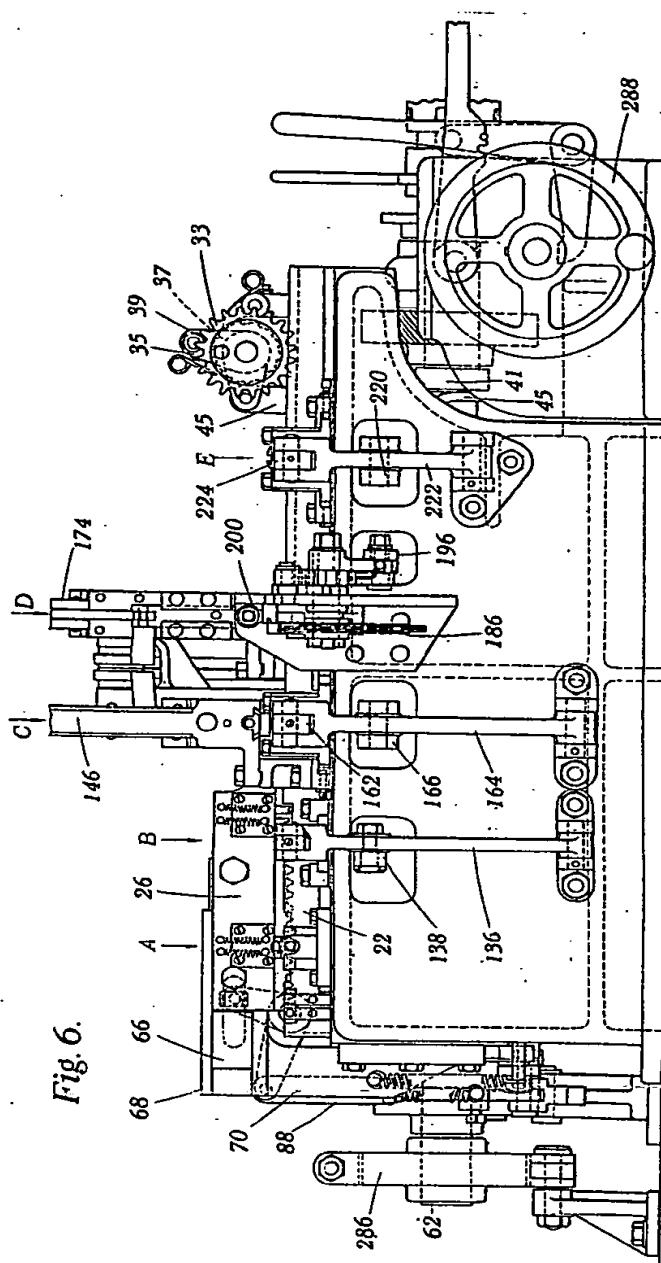


Fig. 6.

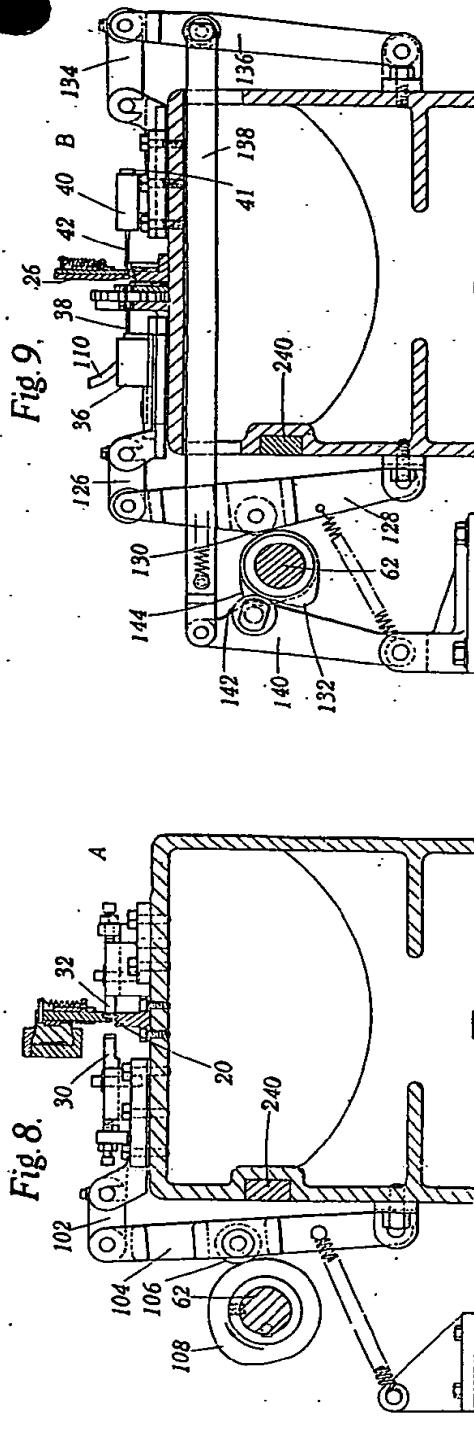


Fig. 9. 26

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Fig

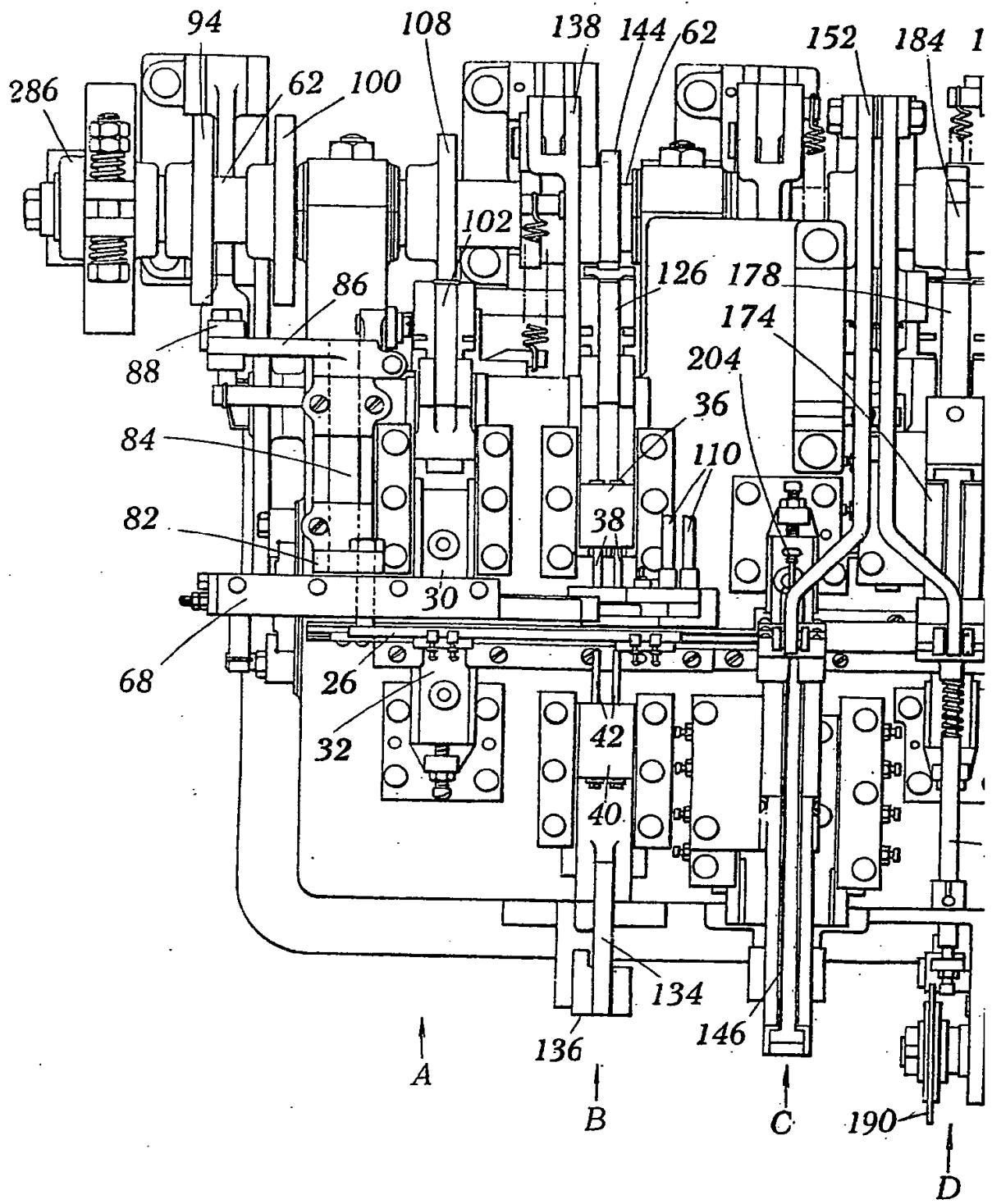
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Fig. 7.

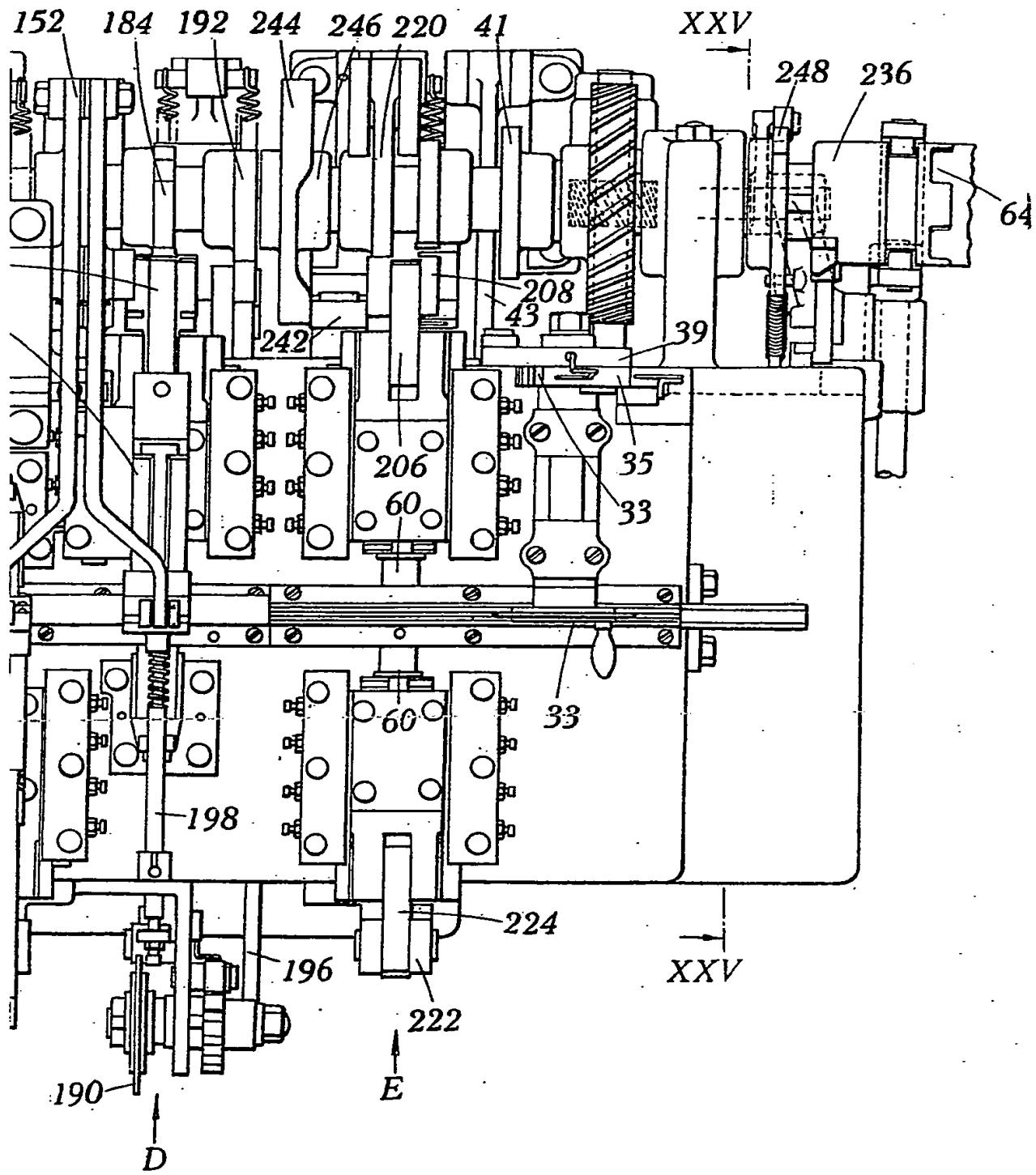
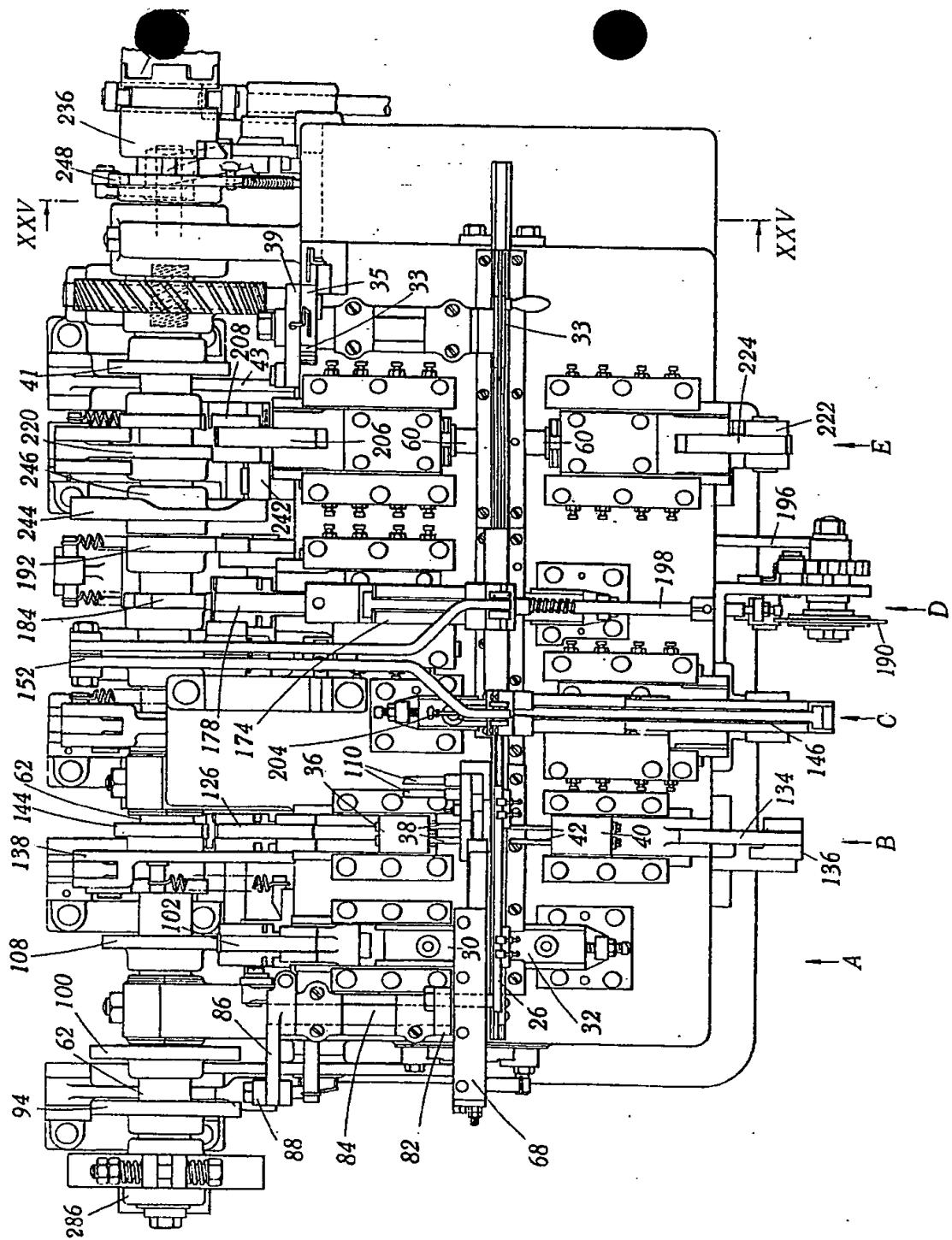


Fig. 7.



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Fig. 11.

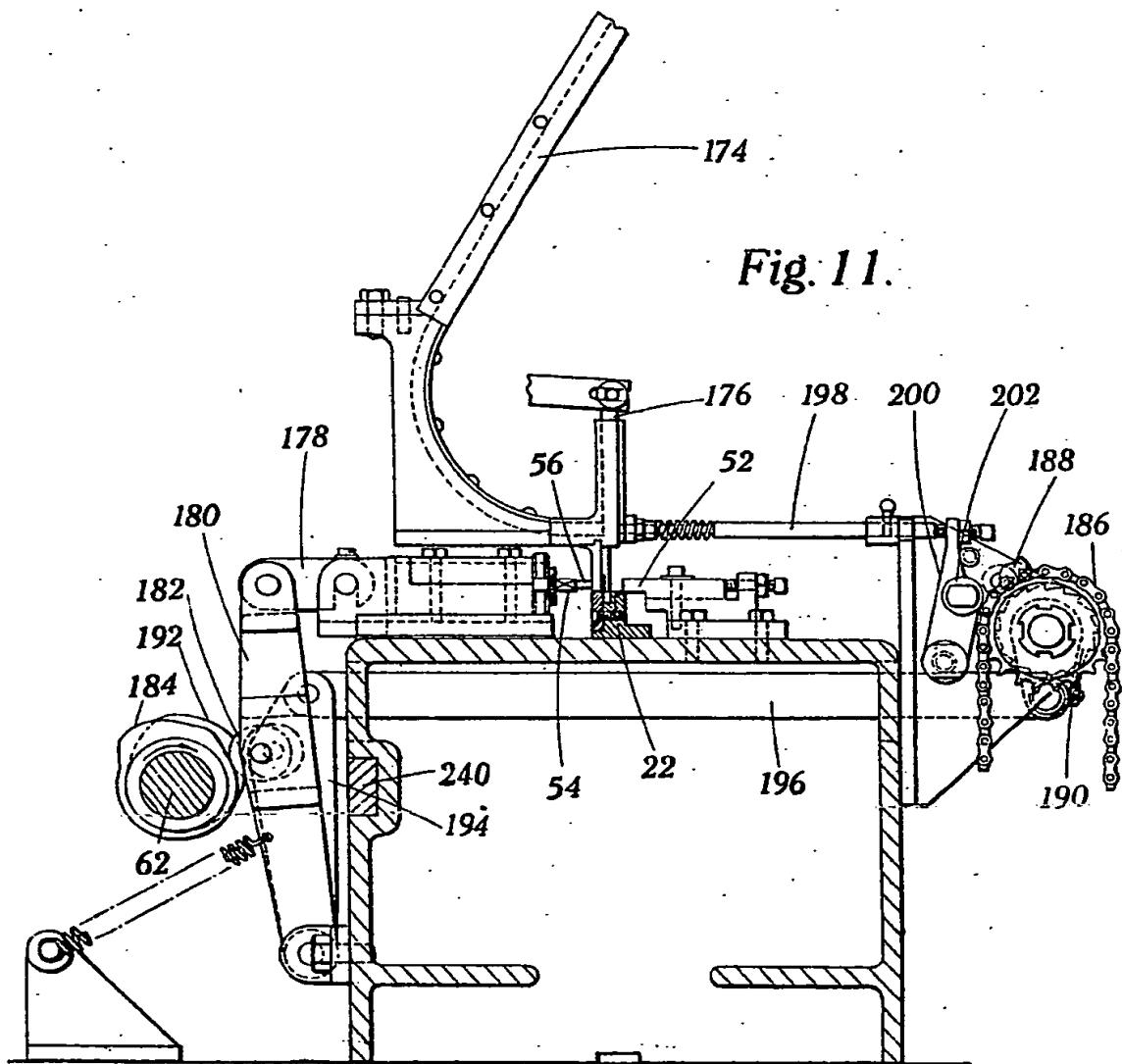


Fig. 12.

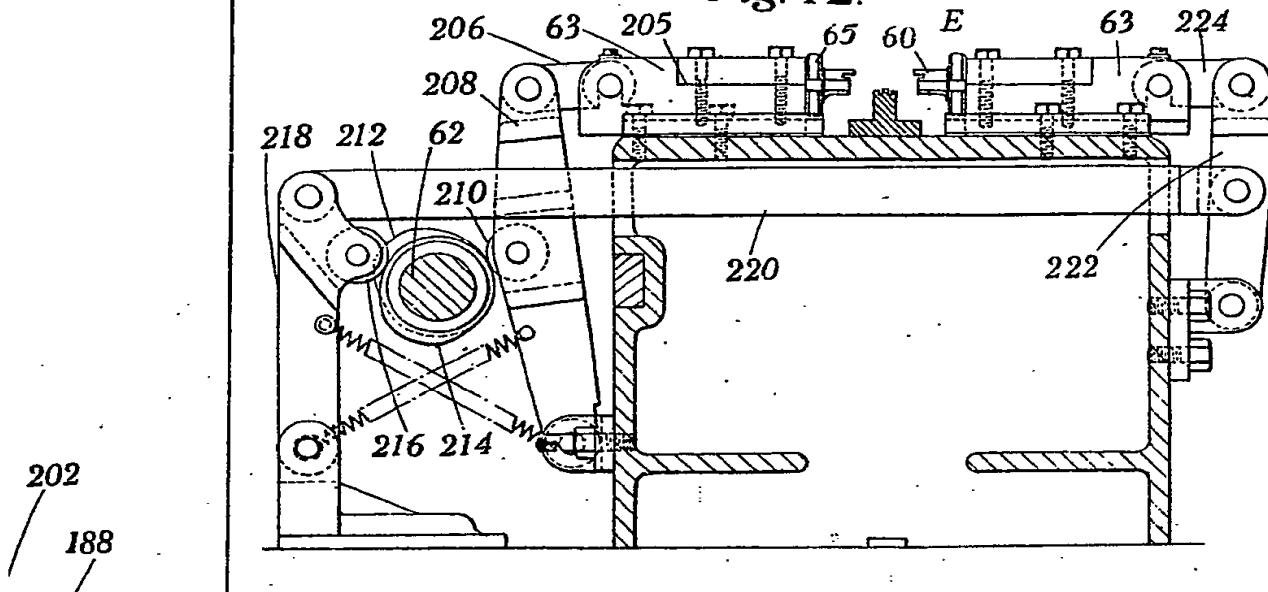
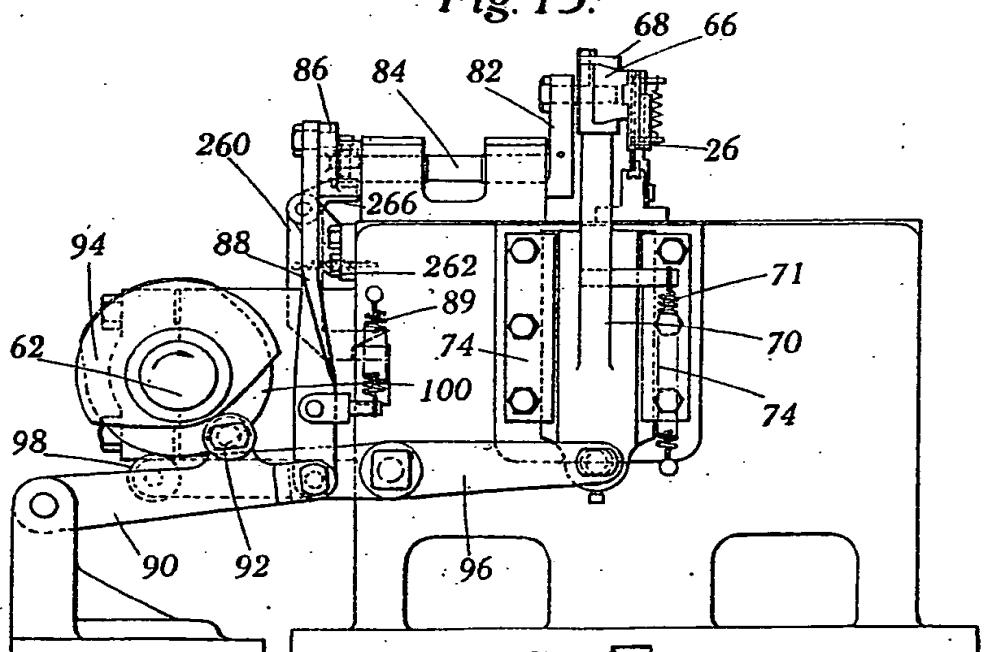


Fig. 13.



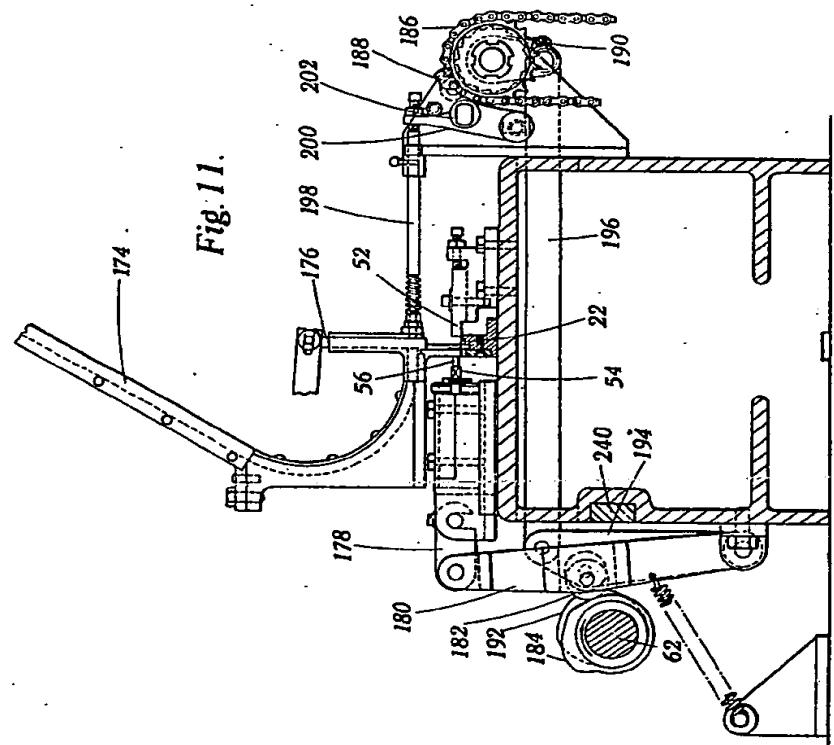


Fig. 11.

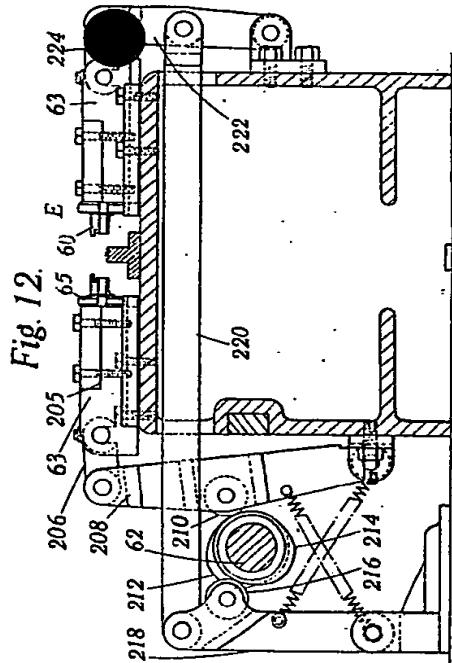


Fig. 12.

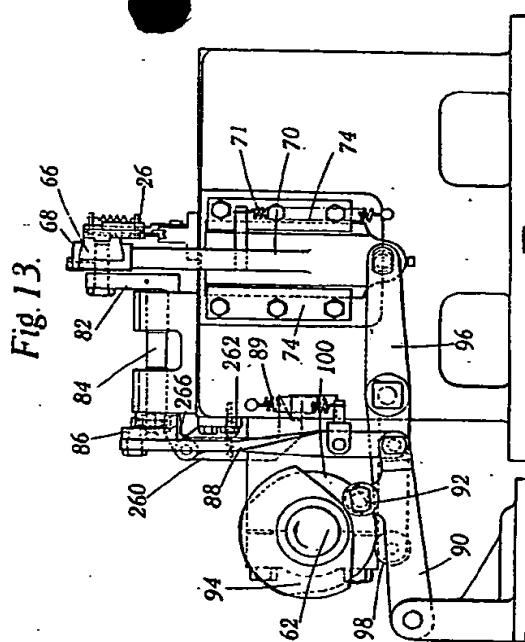


Fig. 13.

384,781 COMPLETE SPECIFICATION

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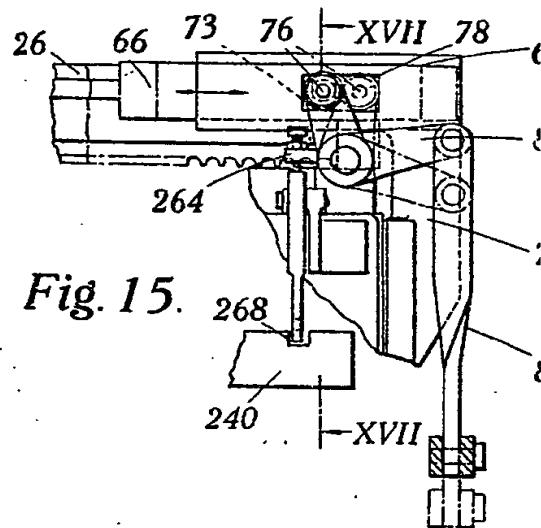
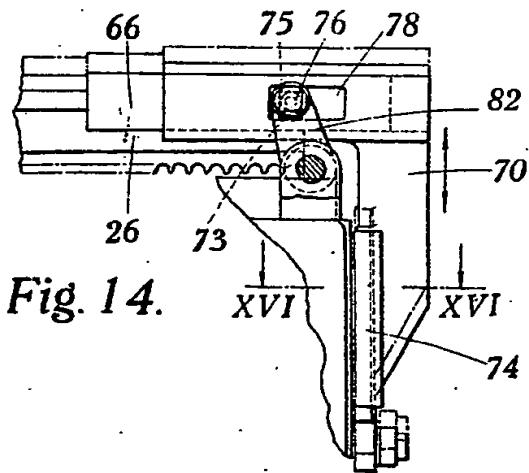
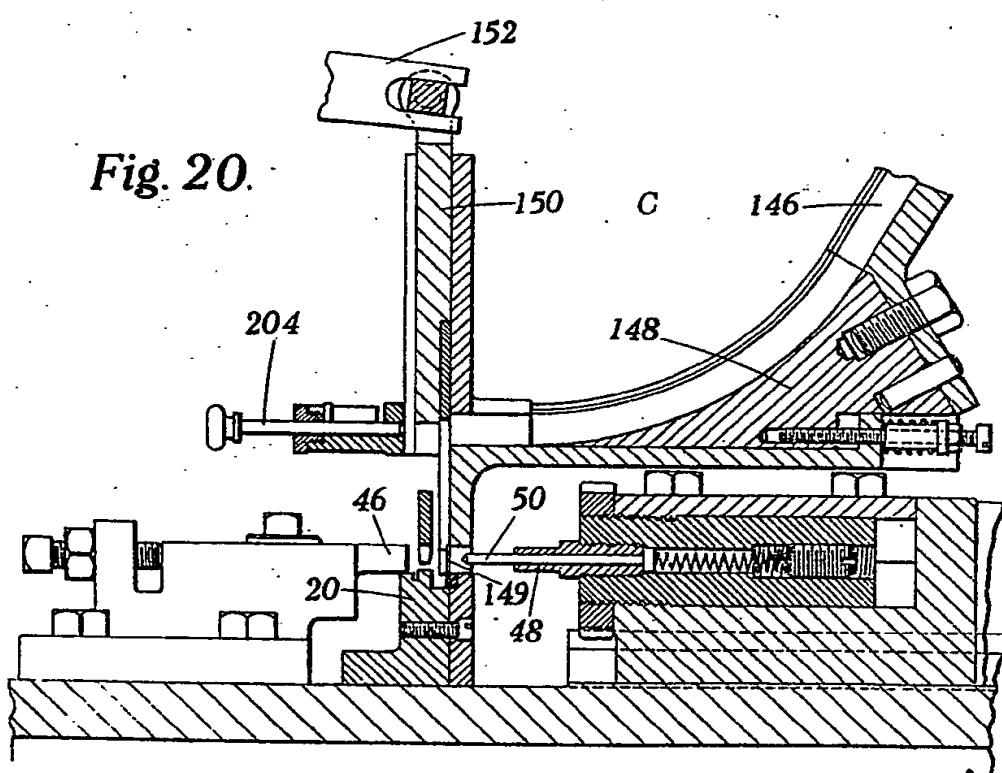


Fig. 20.



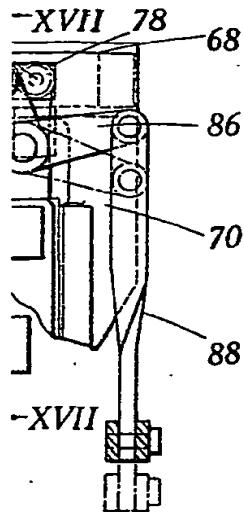


Fig. 16.

Fig. 17.

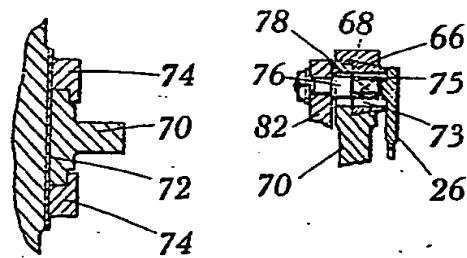


Fig. 18.

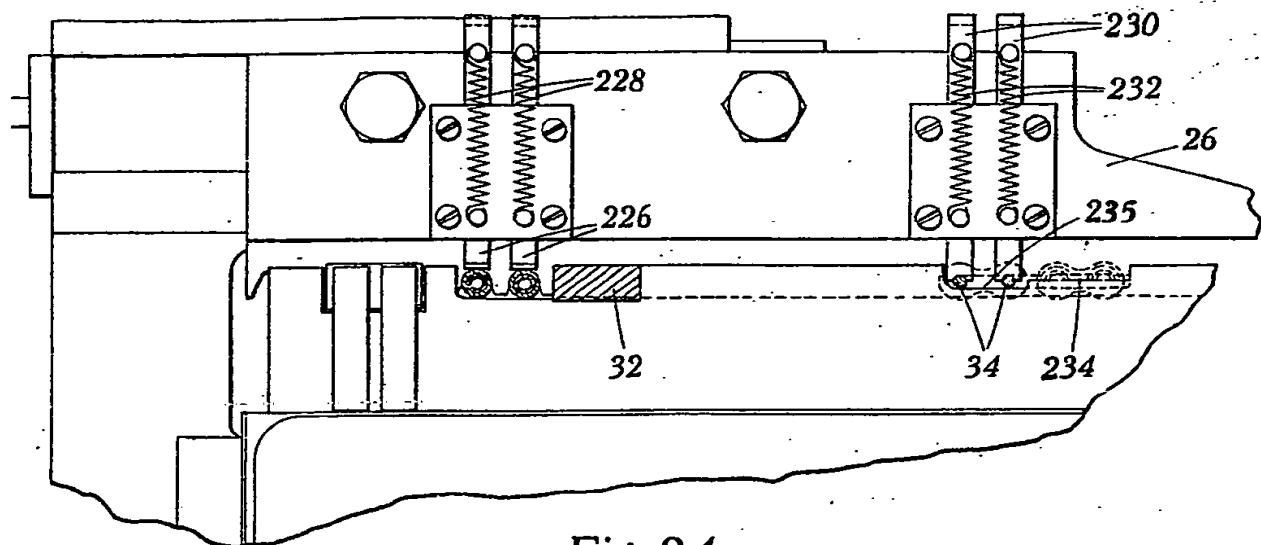


Fig. 24.

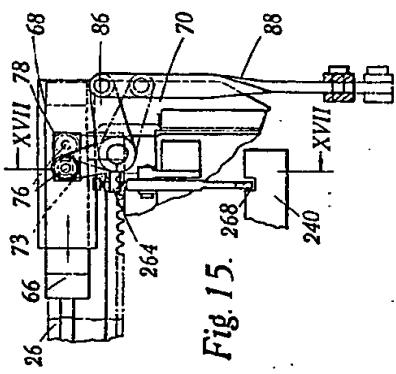
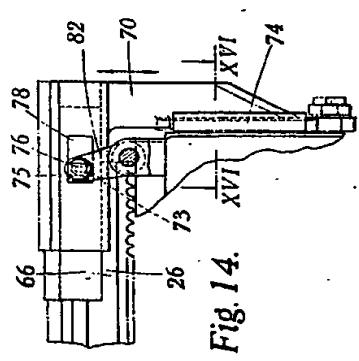


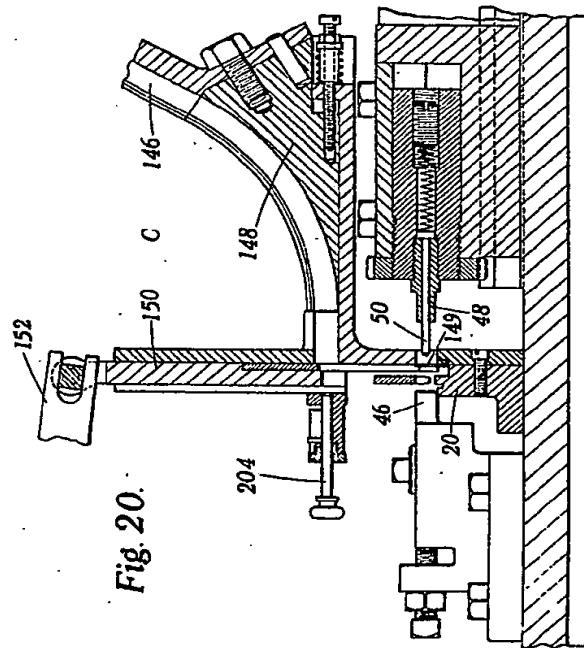
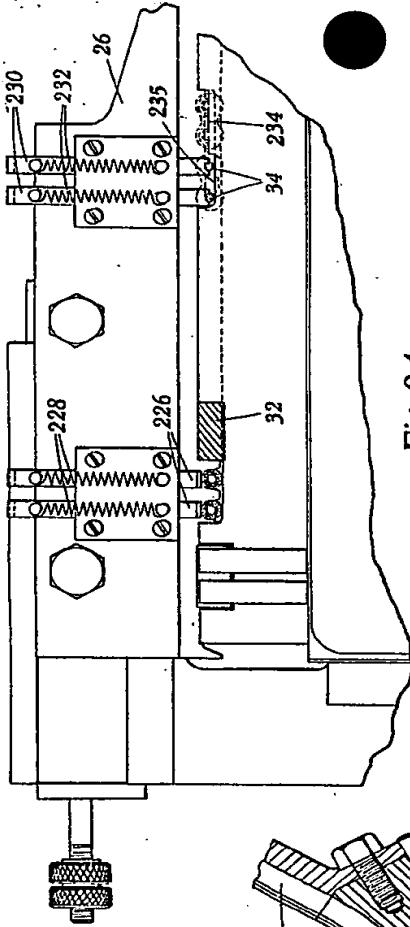
Fig. 17.

Fig. 18.

Fig. 16.

Fig. 17.

Fig. 18.



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Fig. 19.

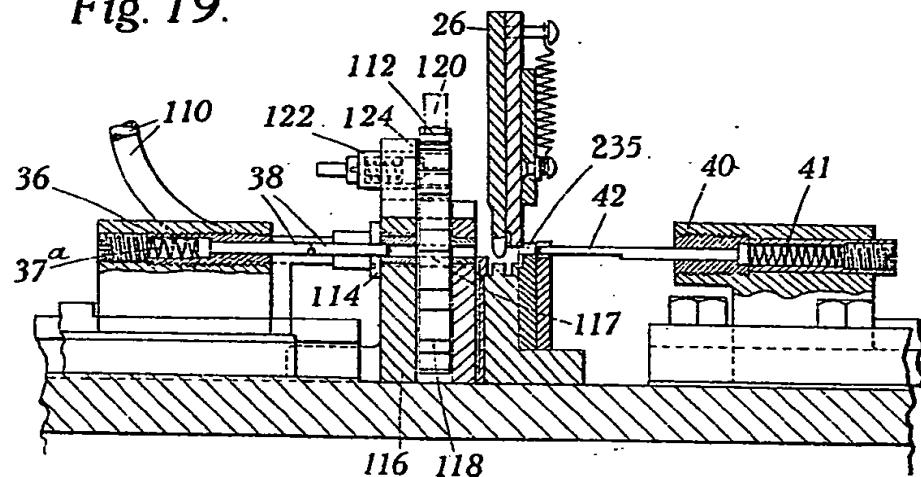


Fig. 22.

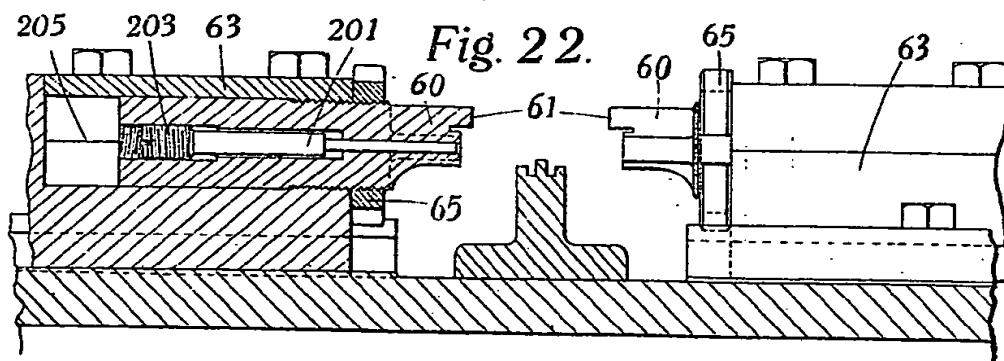
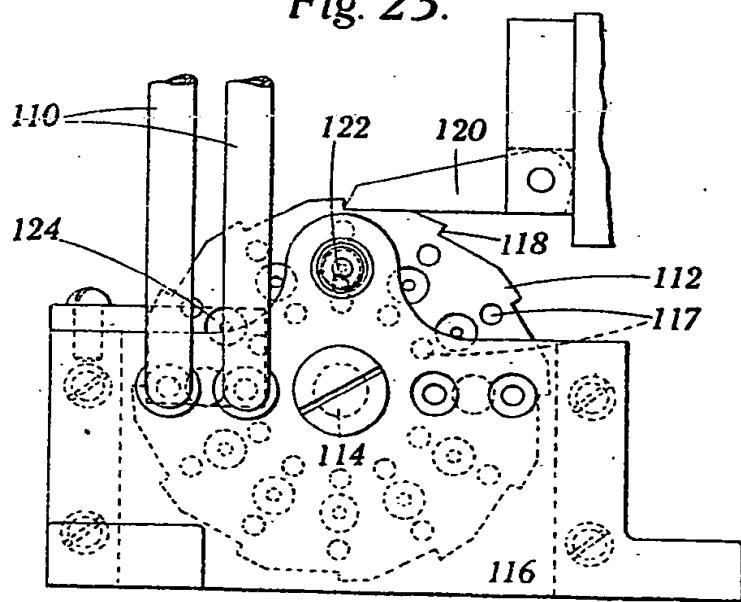


Fig. 23.



[This Drawing is a reproduction of the Original on a reduced scale.]

Fig. 21.

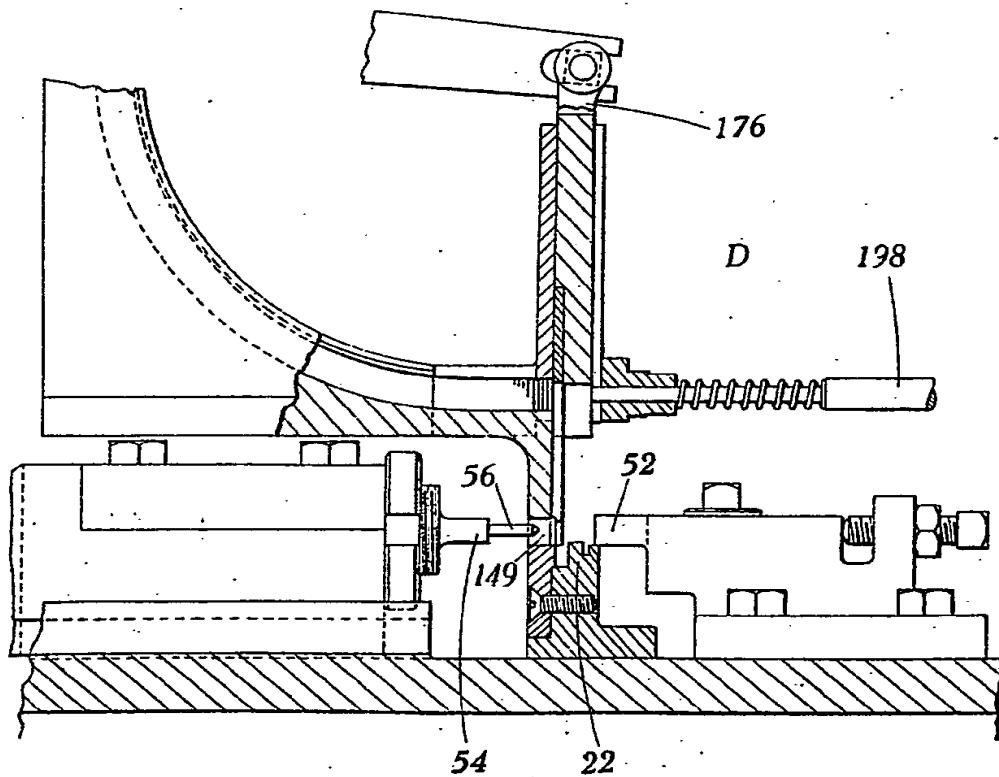


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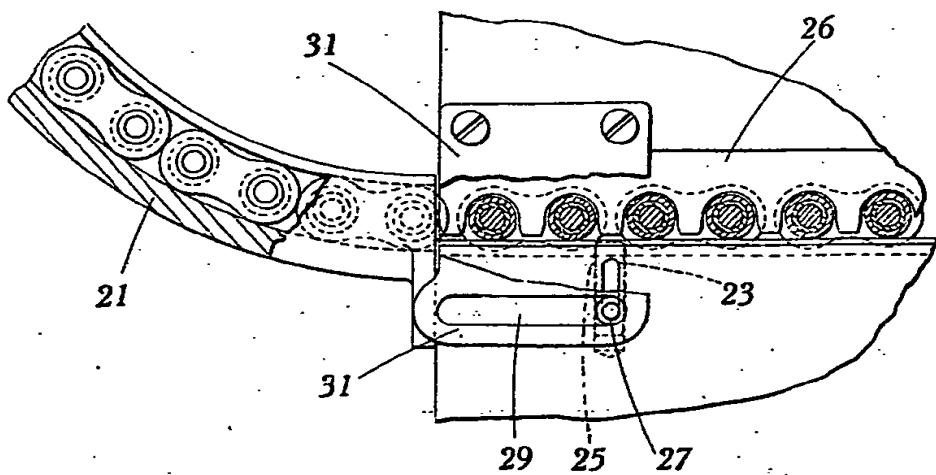


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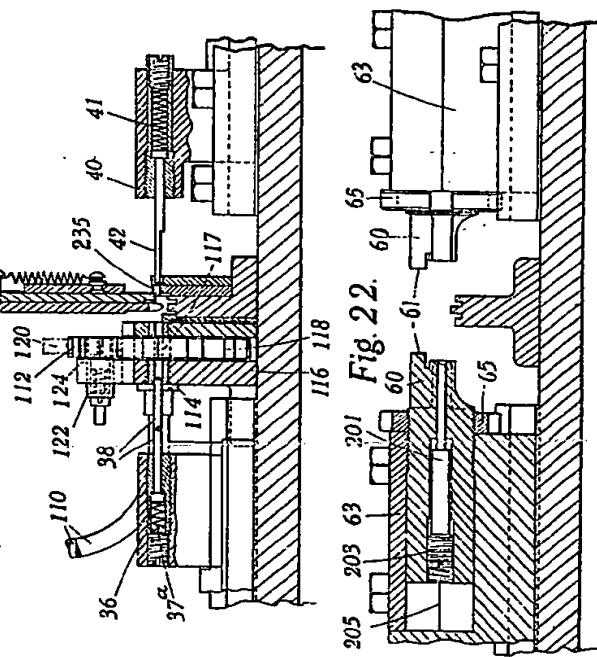


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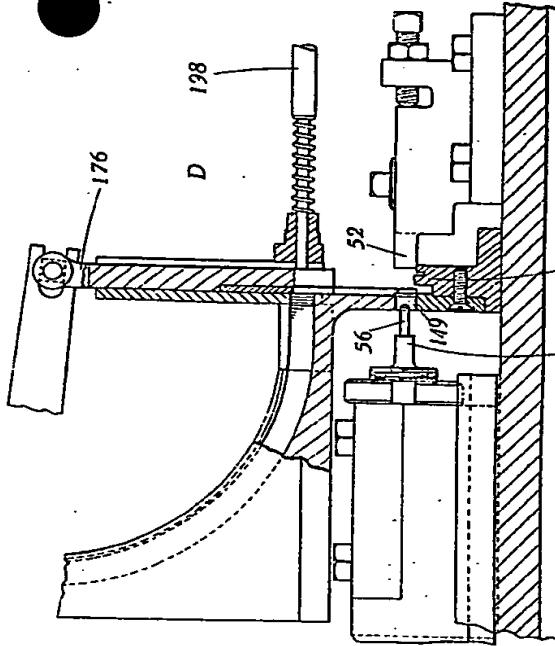
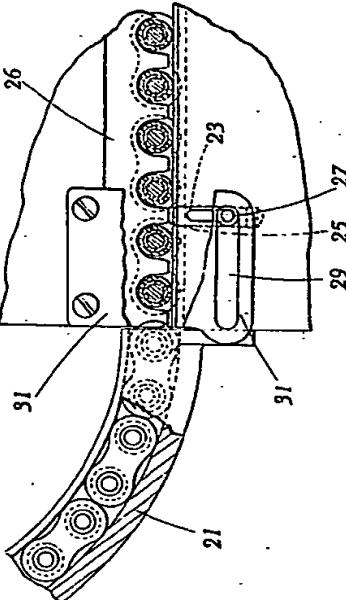


Fig. 29.



[This Drawing is a reproduction of the Original on a reduced scale.]

Fig. 27.

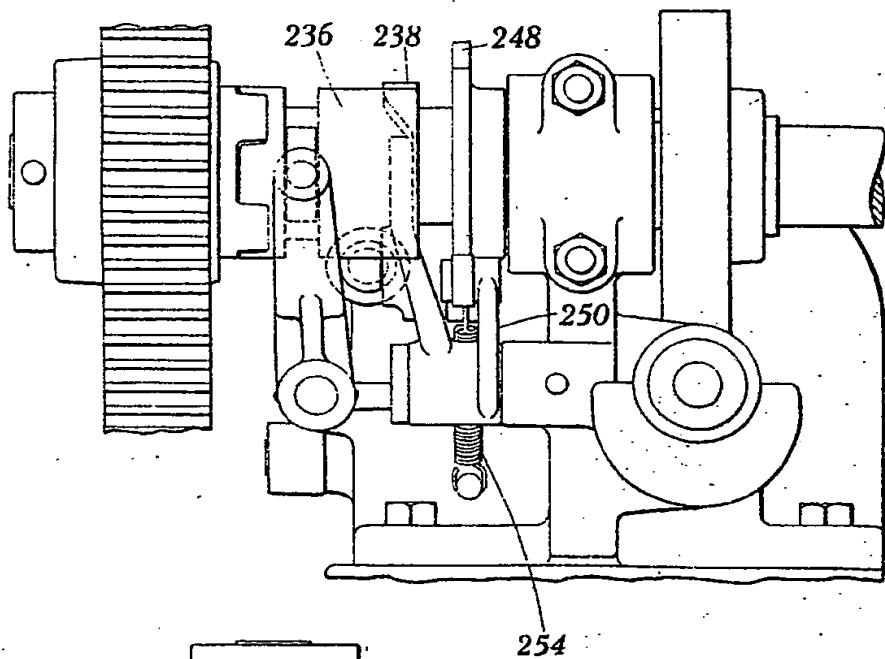
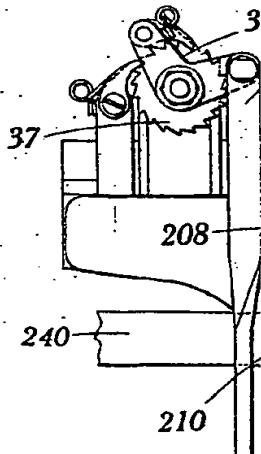
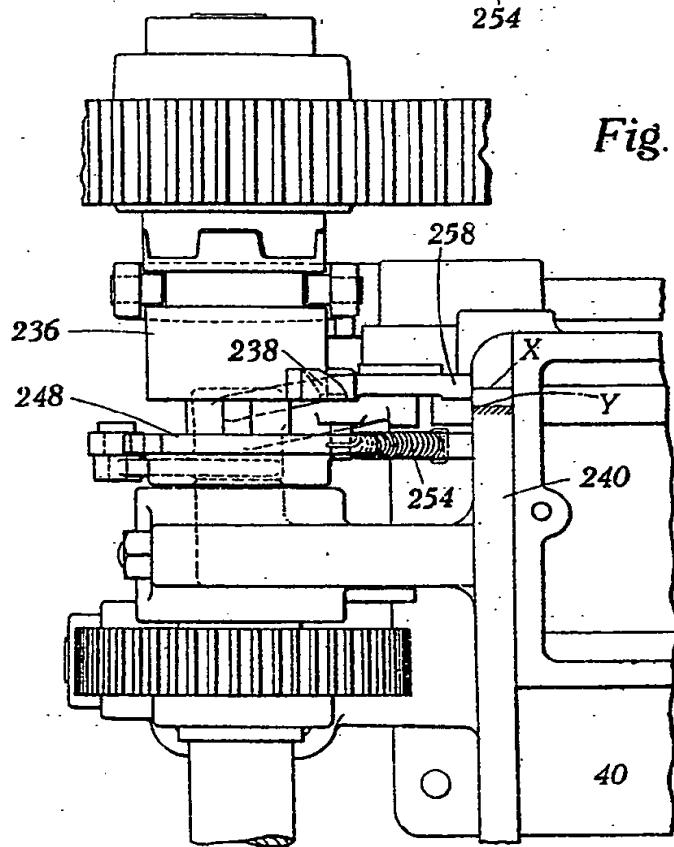


Fig. 26



This Drawing is a reproduction of the Original on a reduced scale.

Fig. 25.

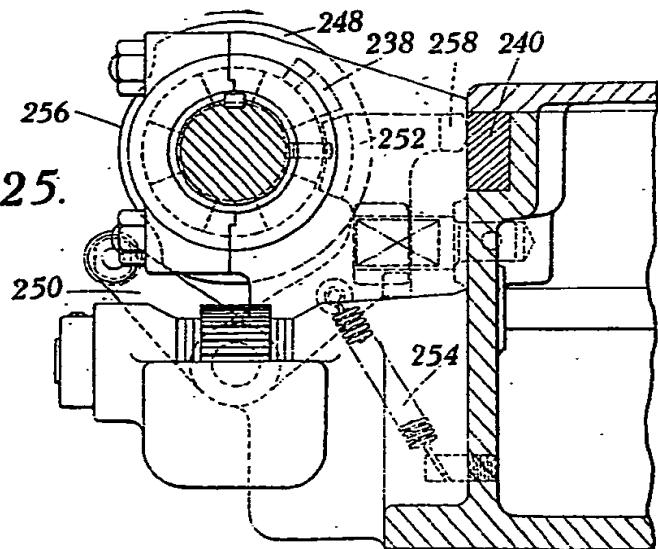
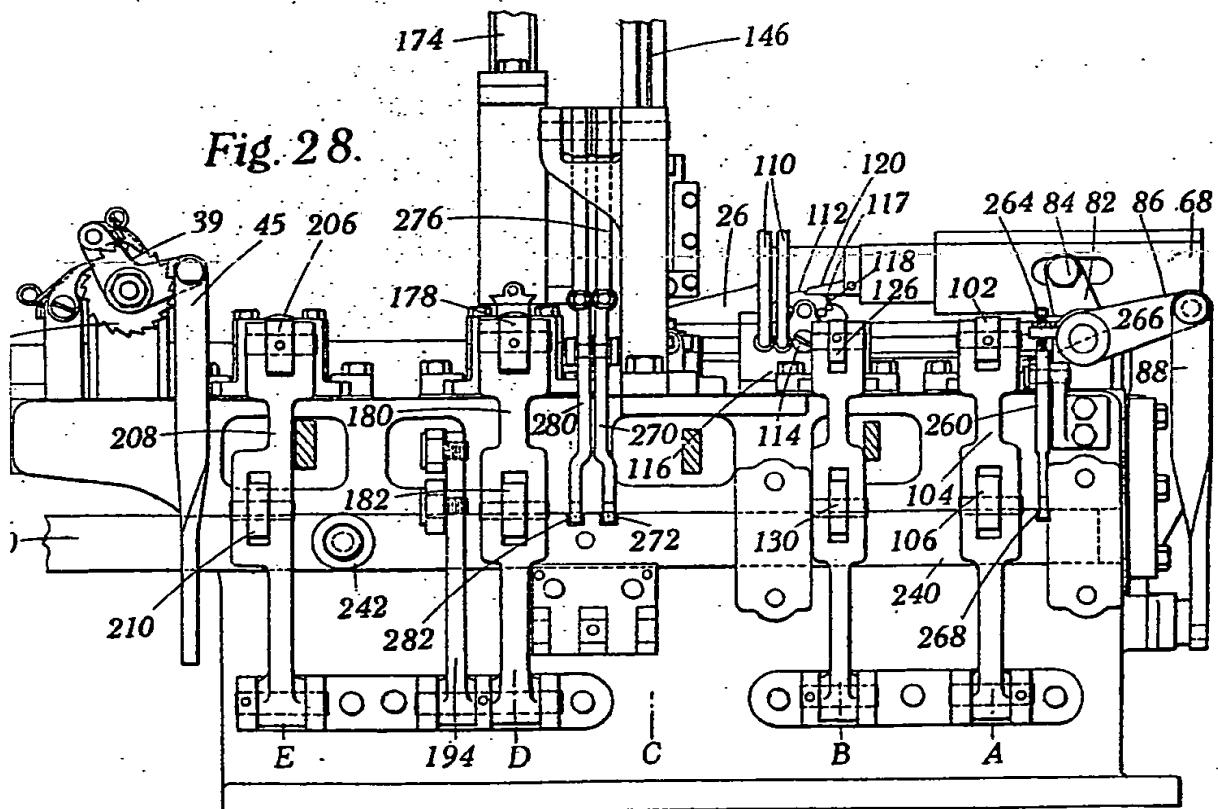


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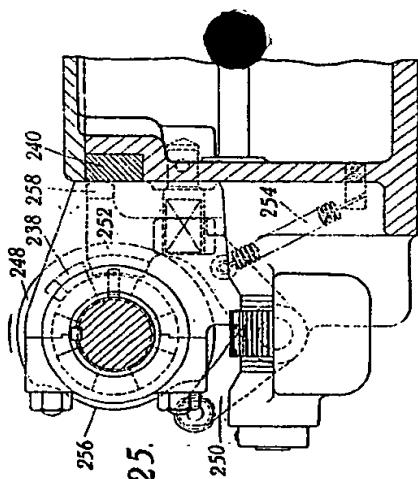


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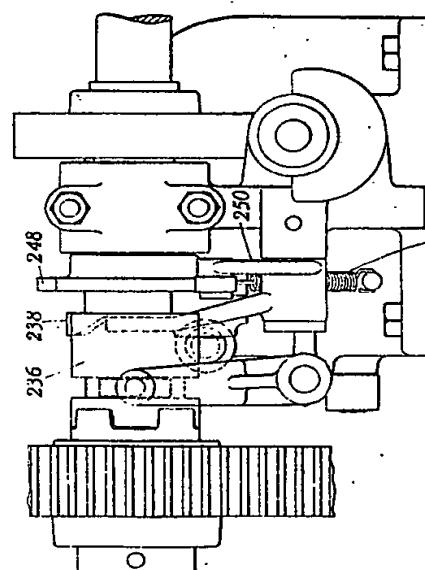


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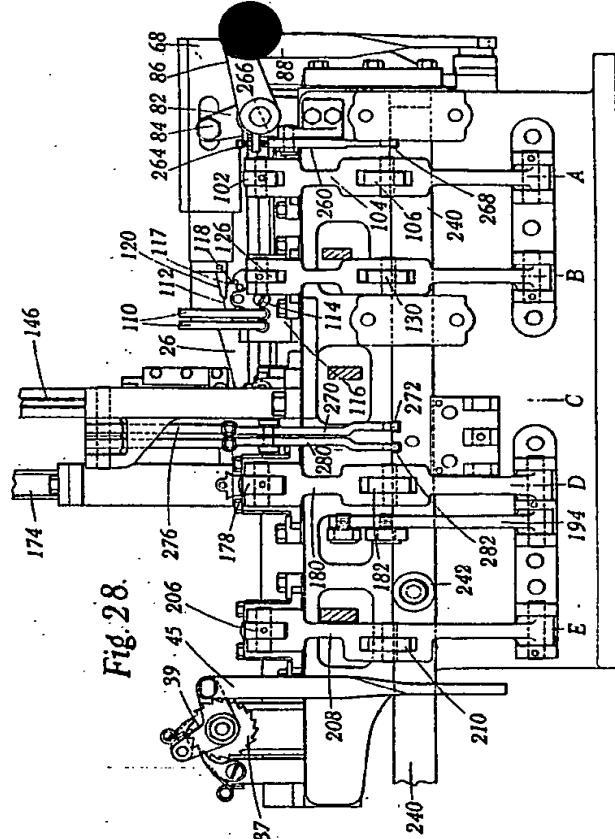


Fig. 2

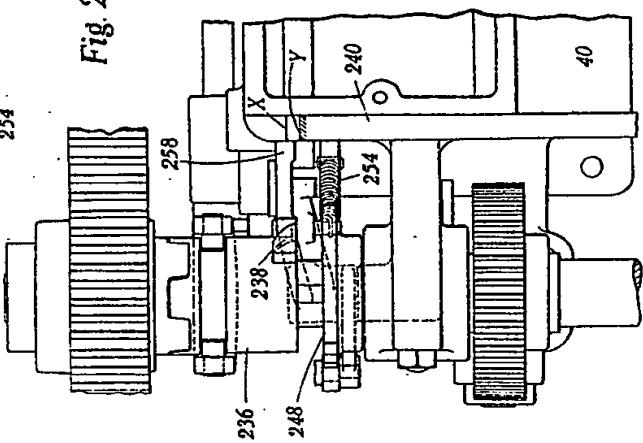


Fig. 26

[This drawing is a reproduction of the Original on a reduced scale.]



This Drawing is a reproduction of the Original on a reduced scale.

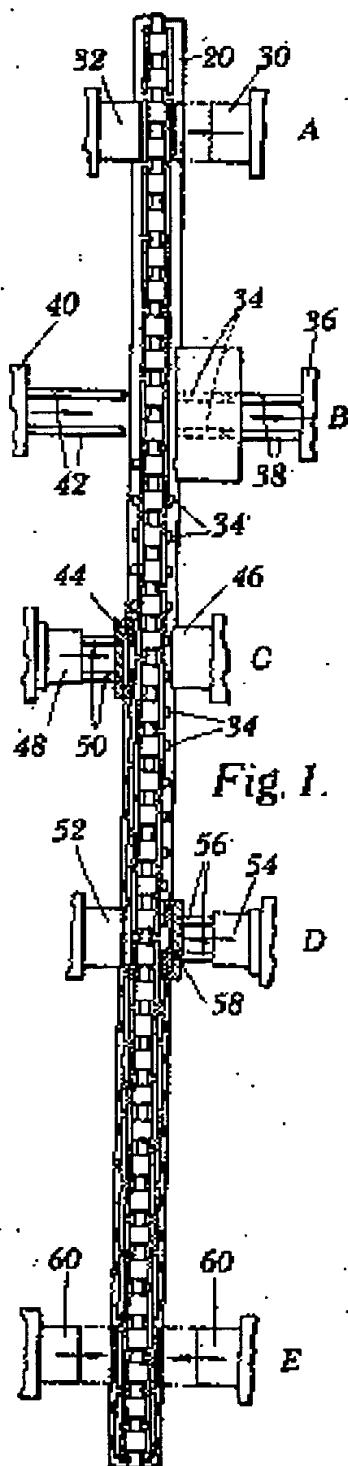


Fig. 1.

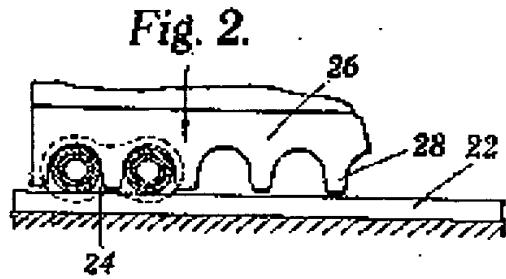


Fig. 2.

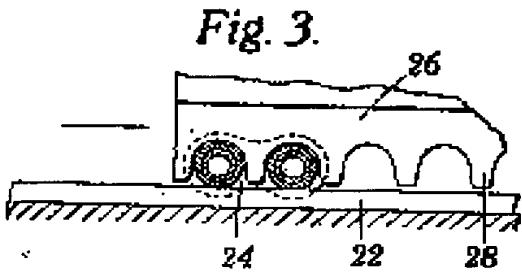


Fig. 3.

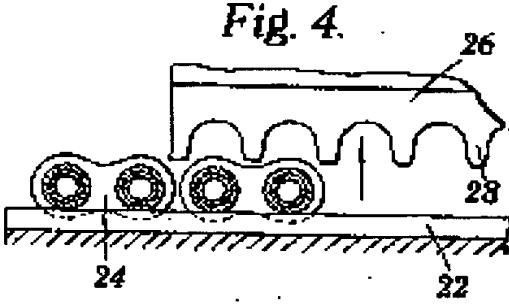


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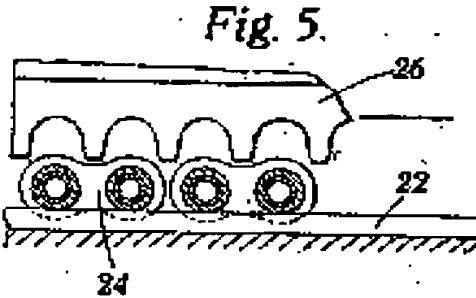
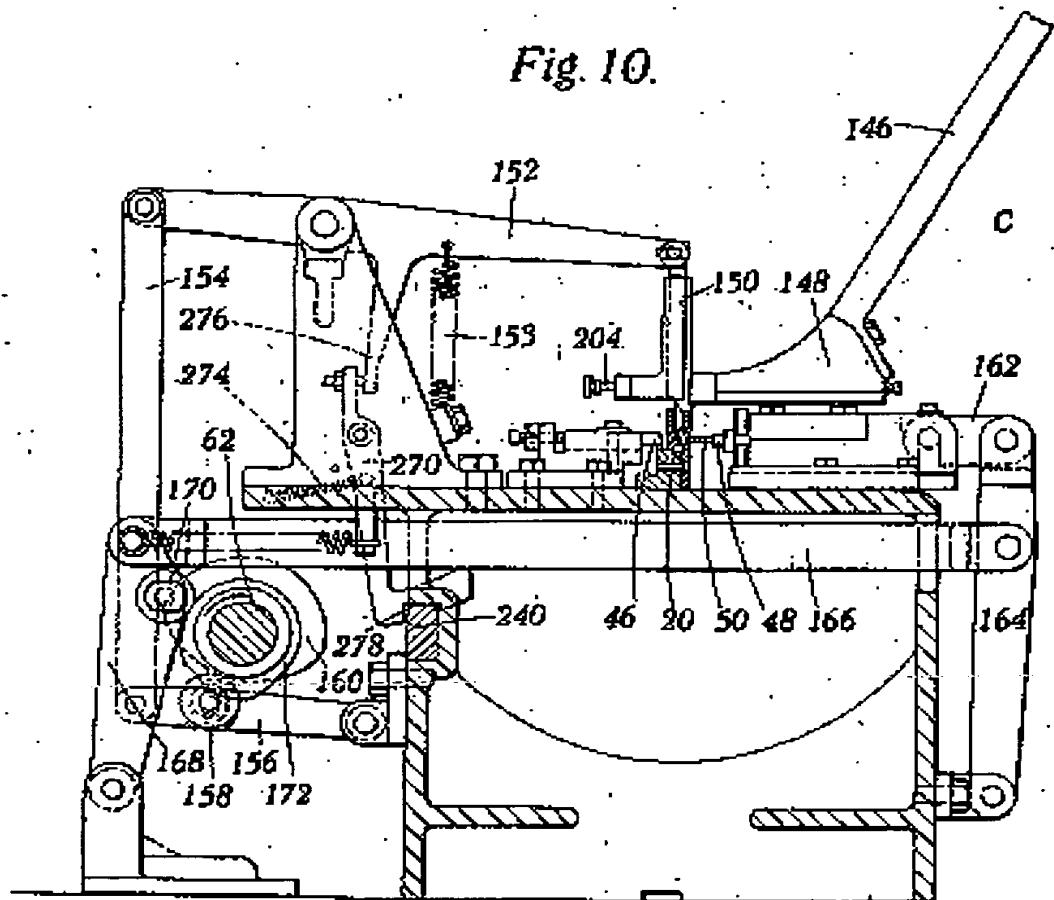
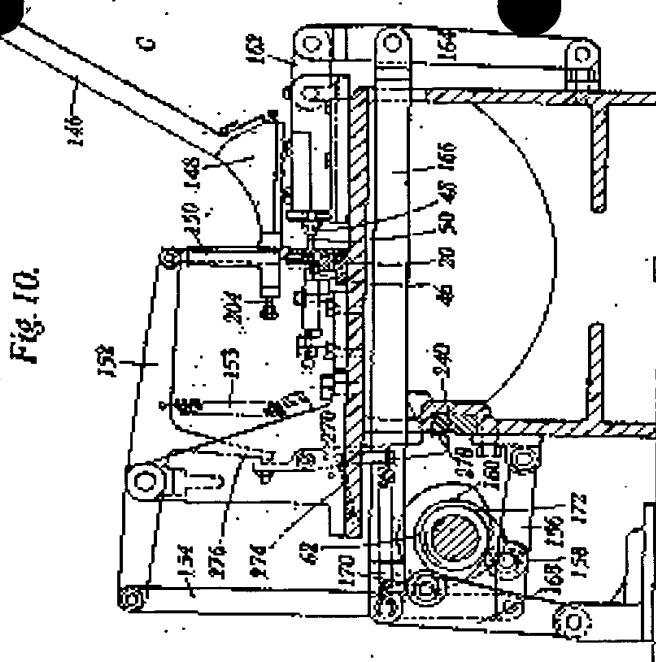
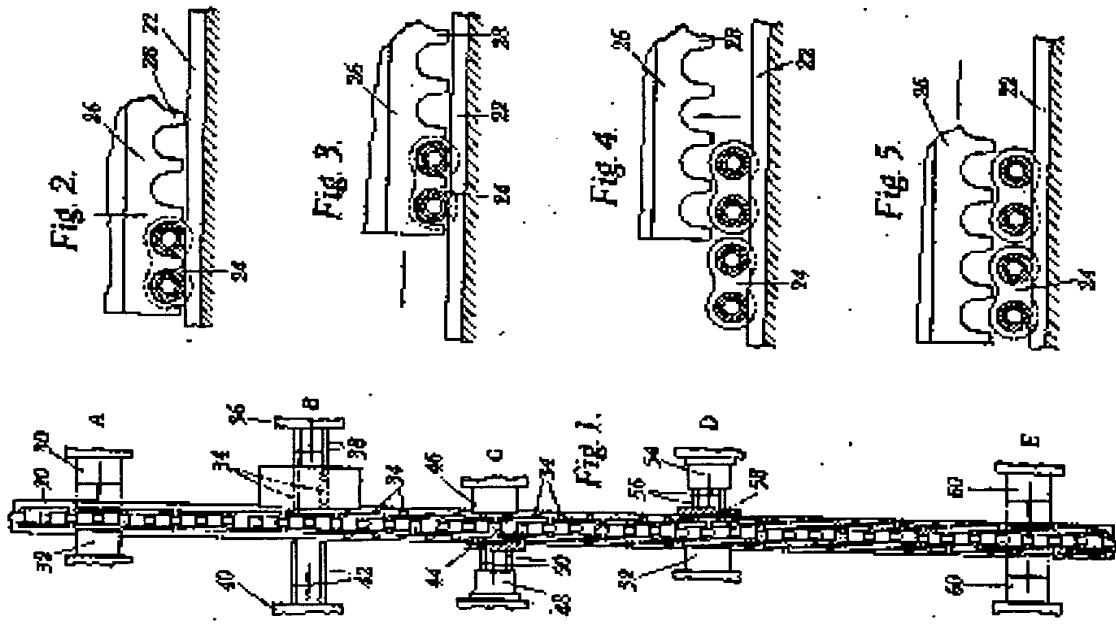


Fig. 5.

Fig. 10.





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Fig. 6.

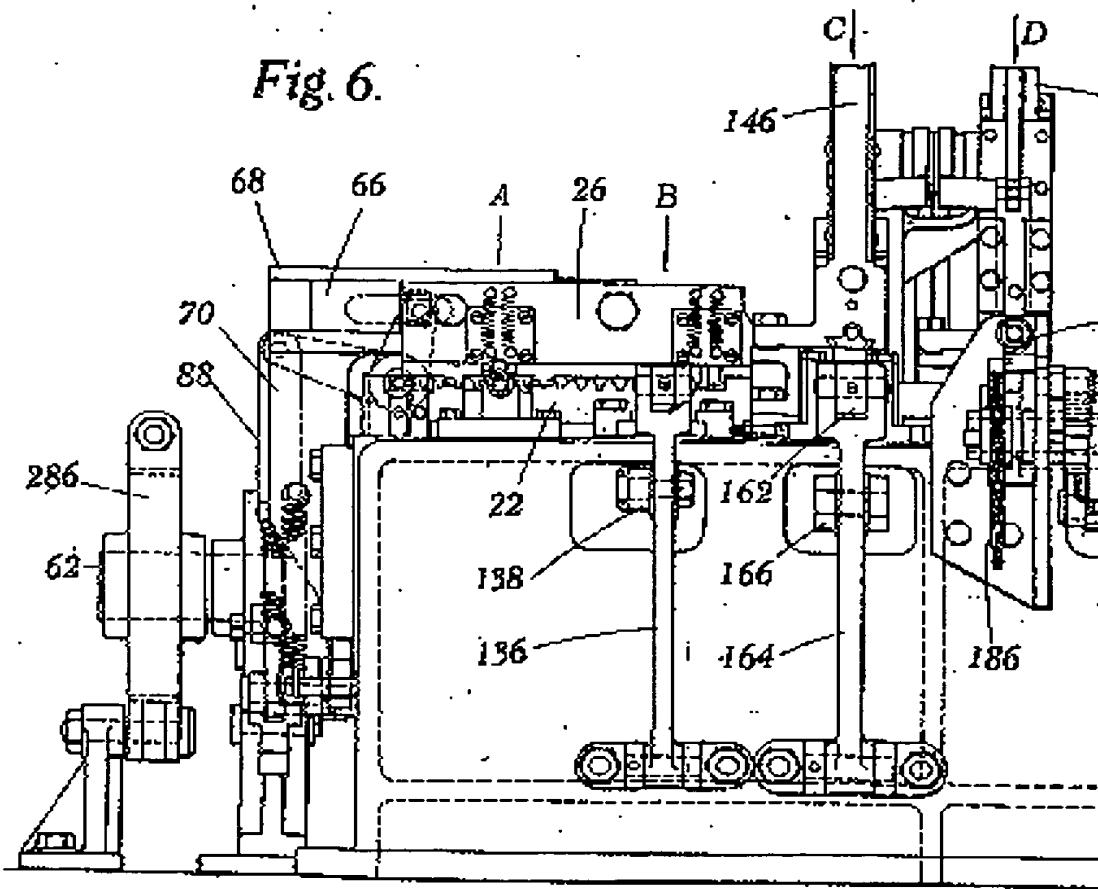
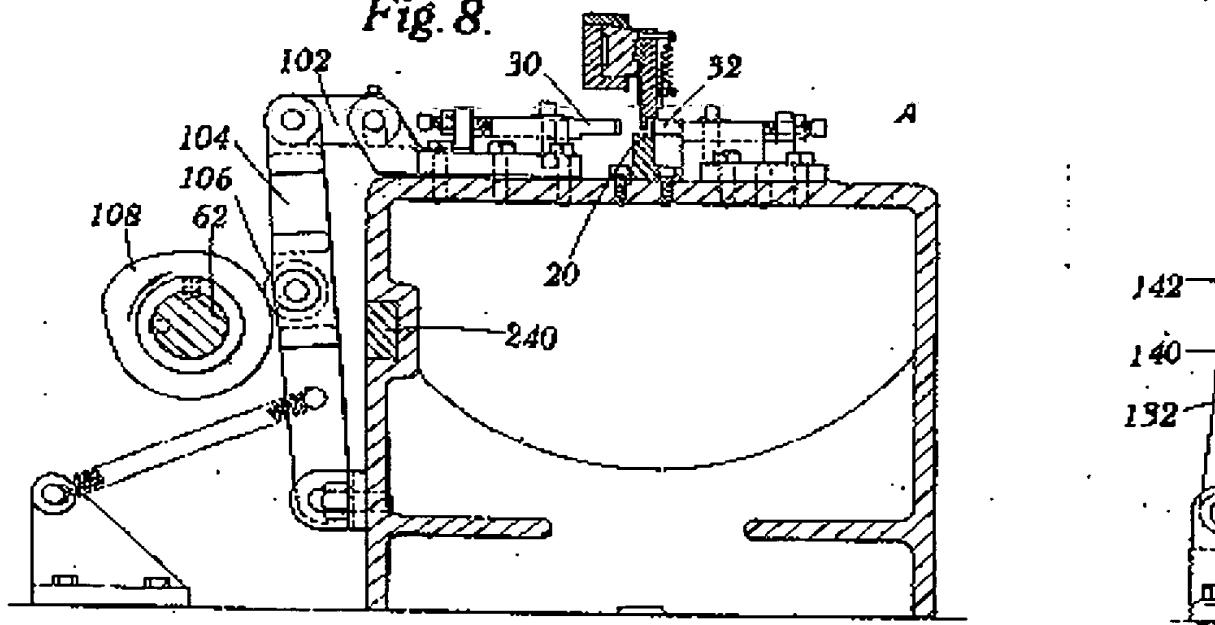


Fig. 8.



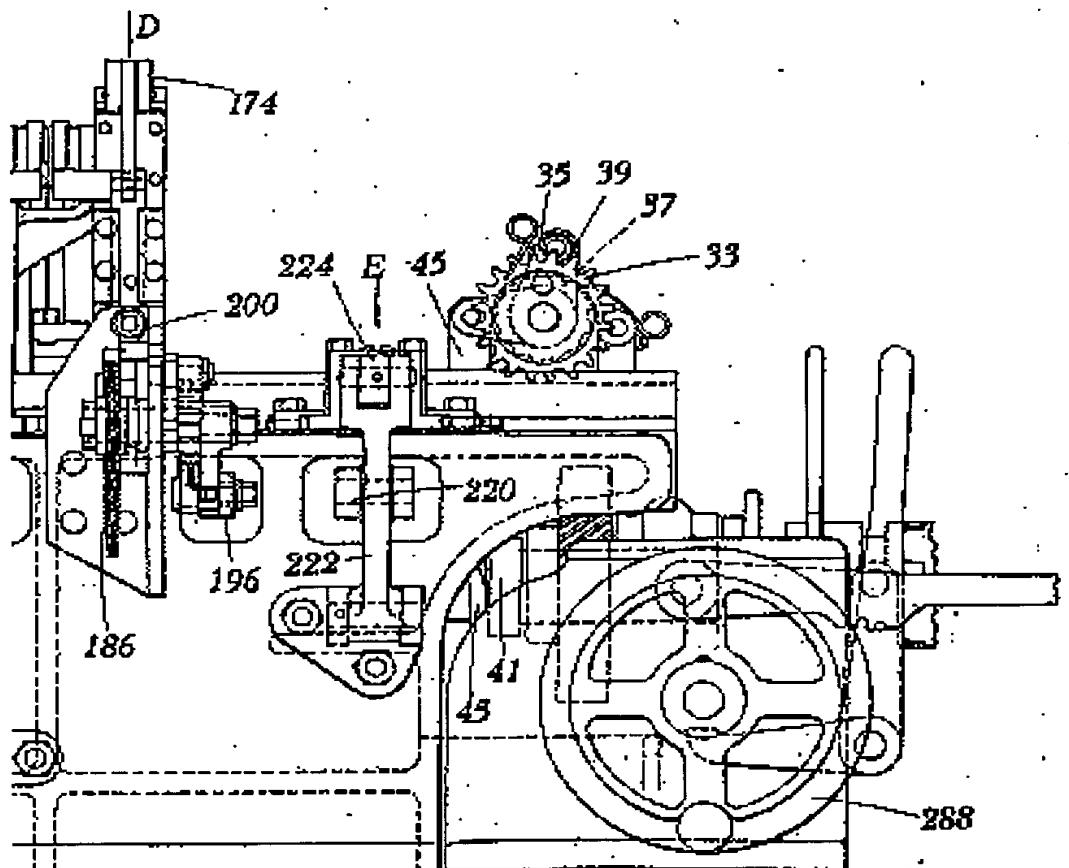


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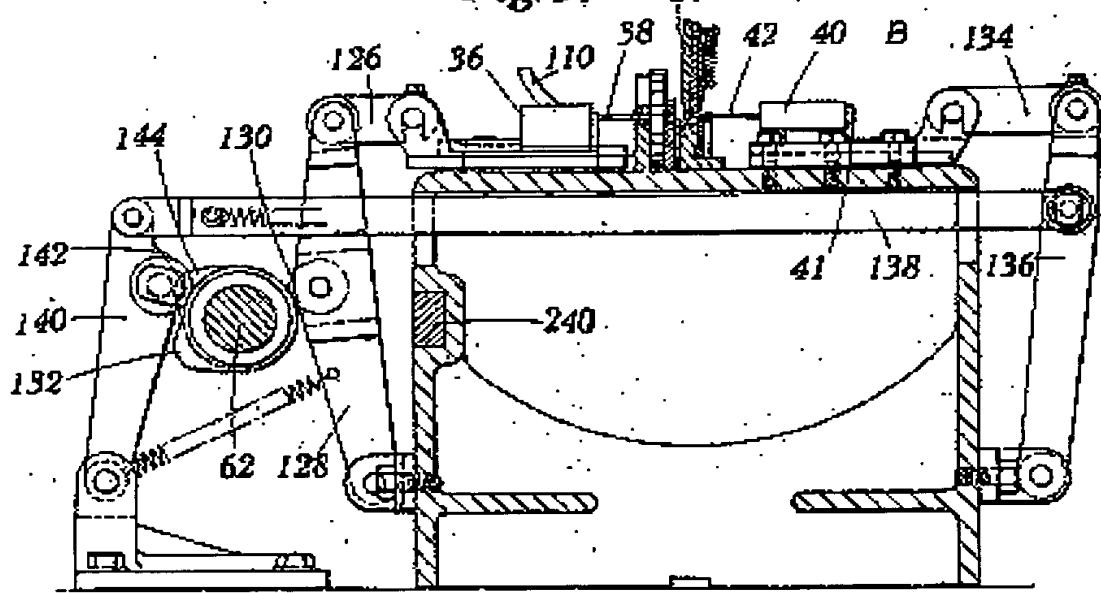


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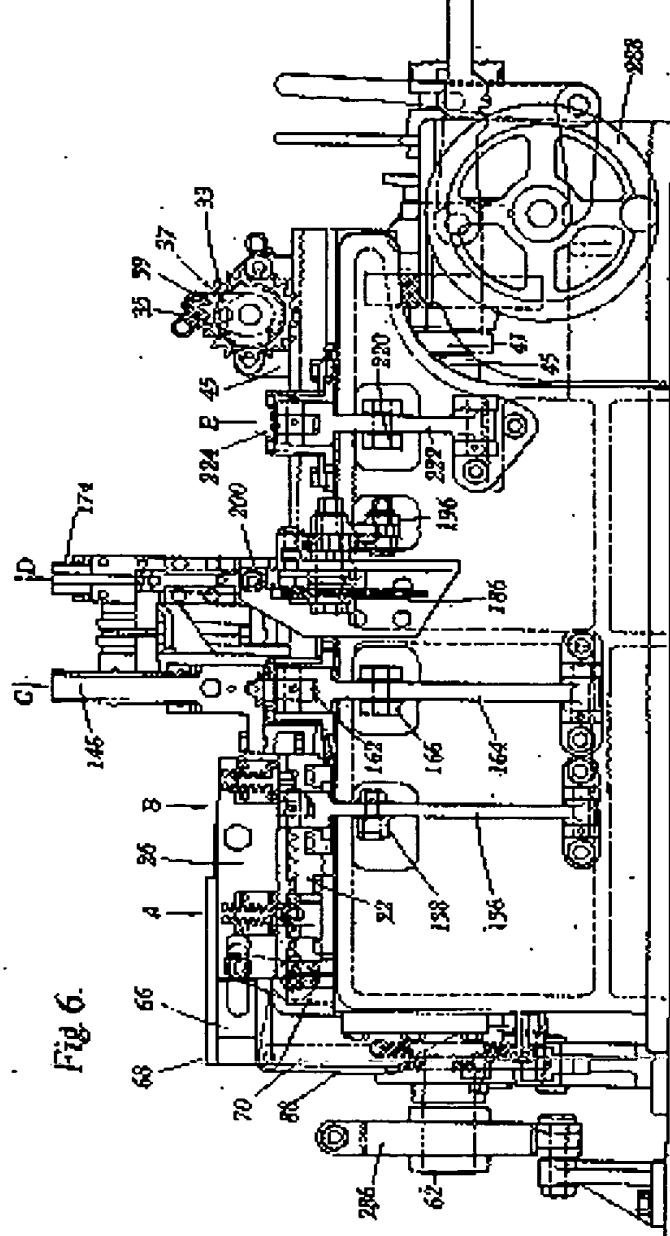


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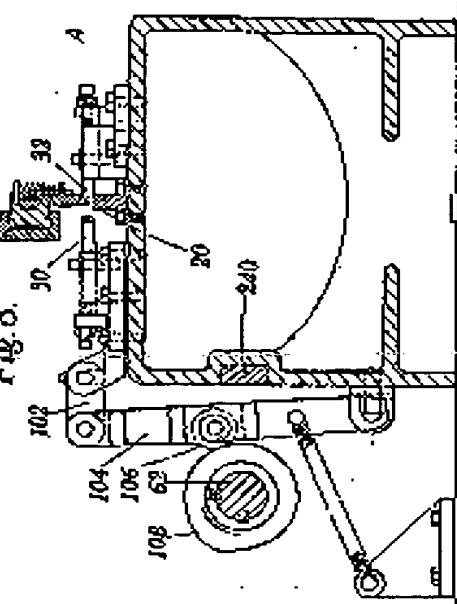
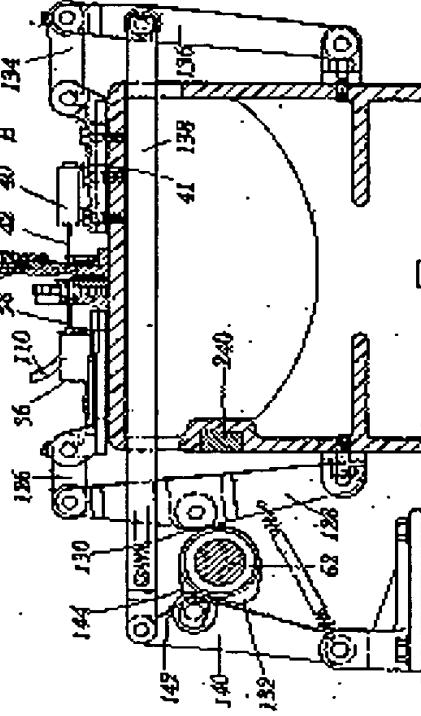


Fig. 9.



Fig

[This Drawing is a full-size reproduction of the Original.]

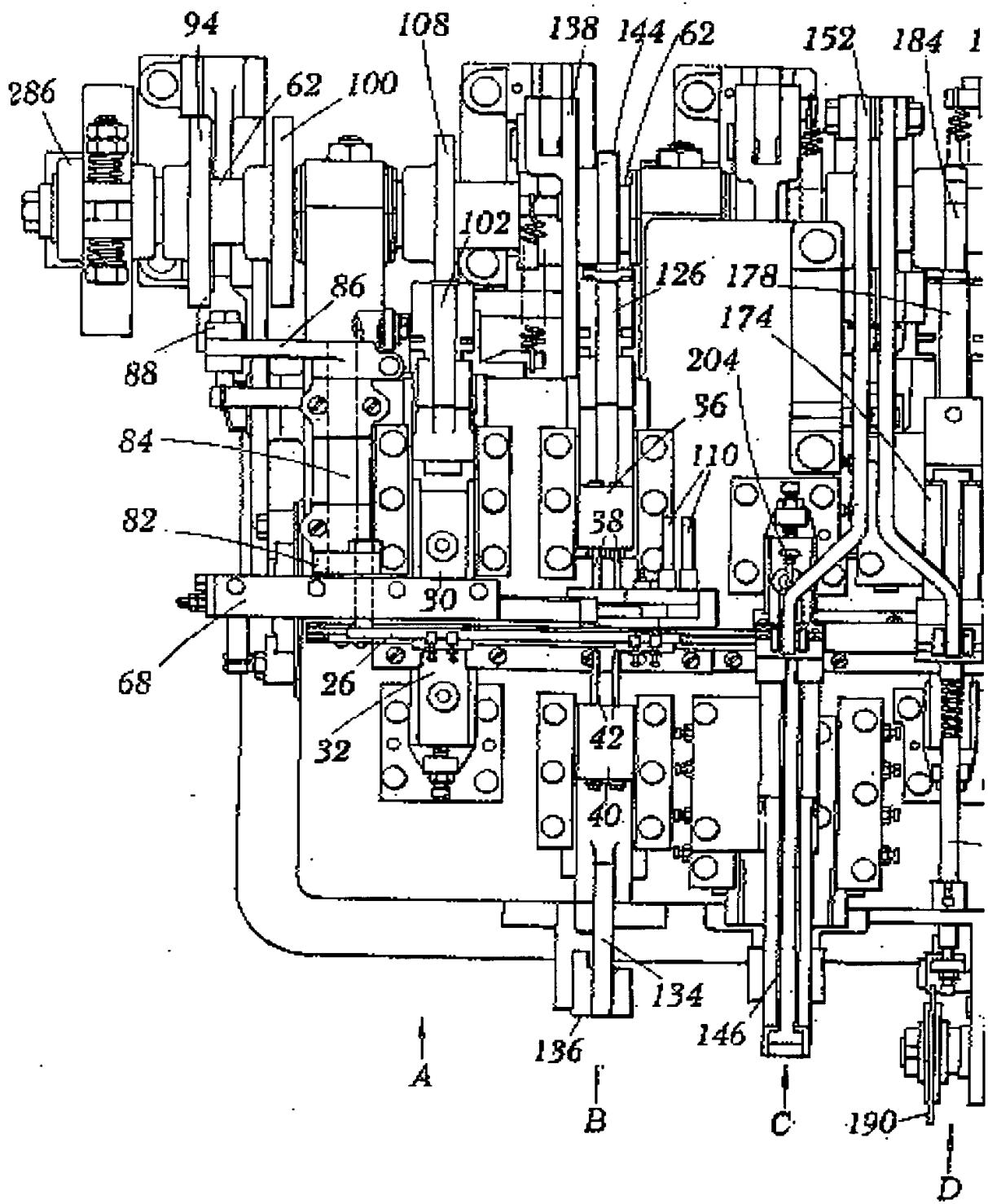
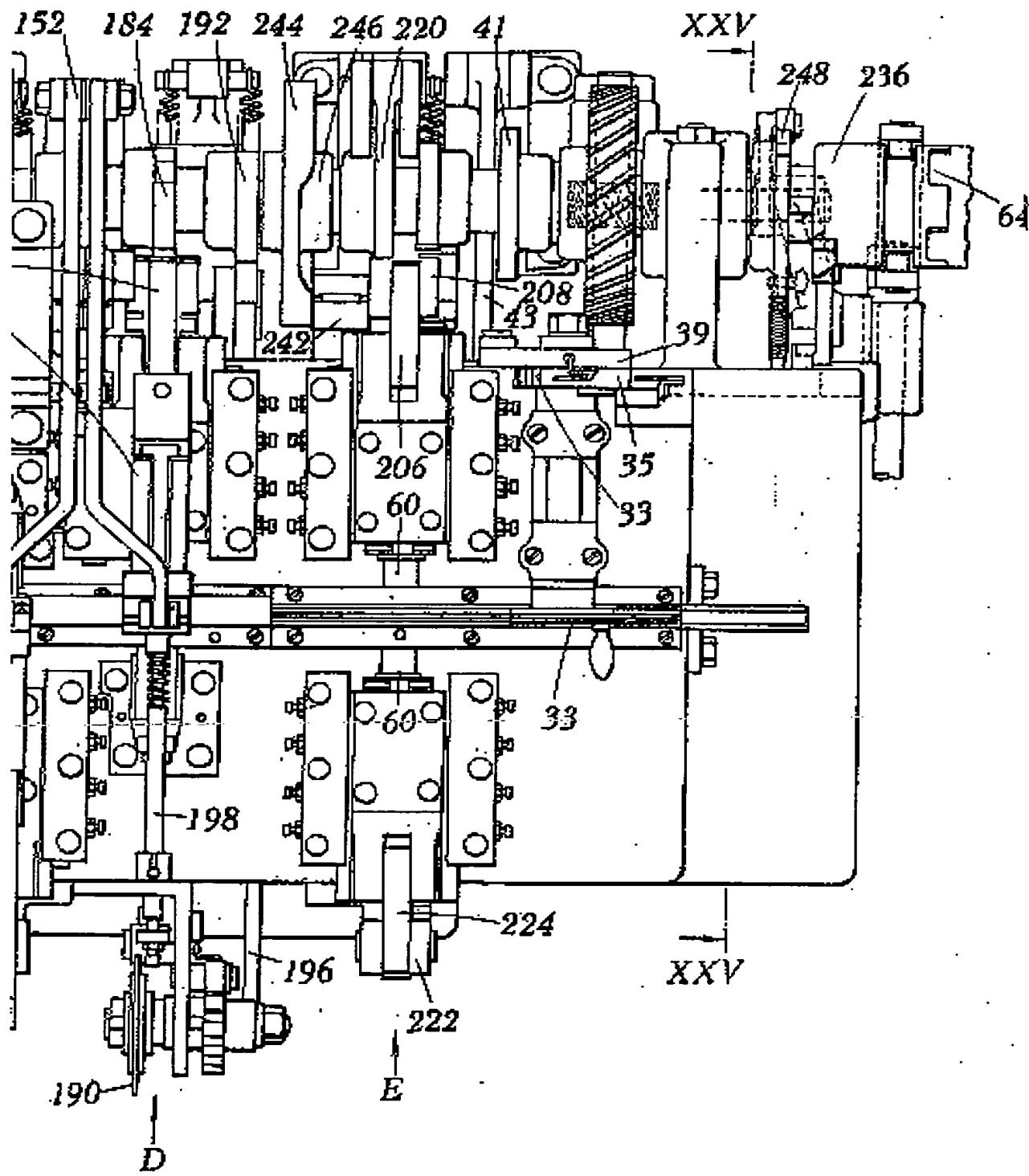
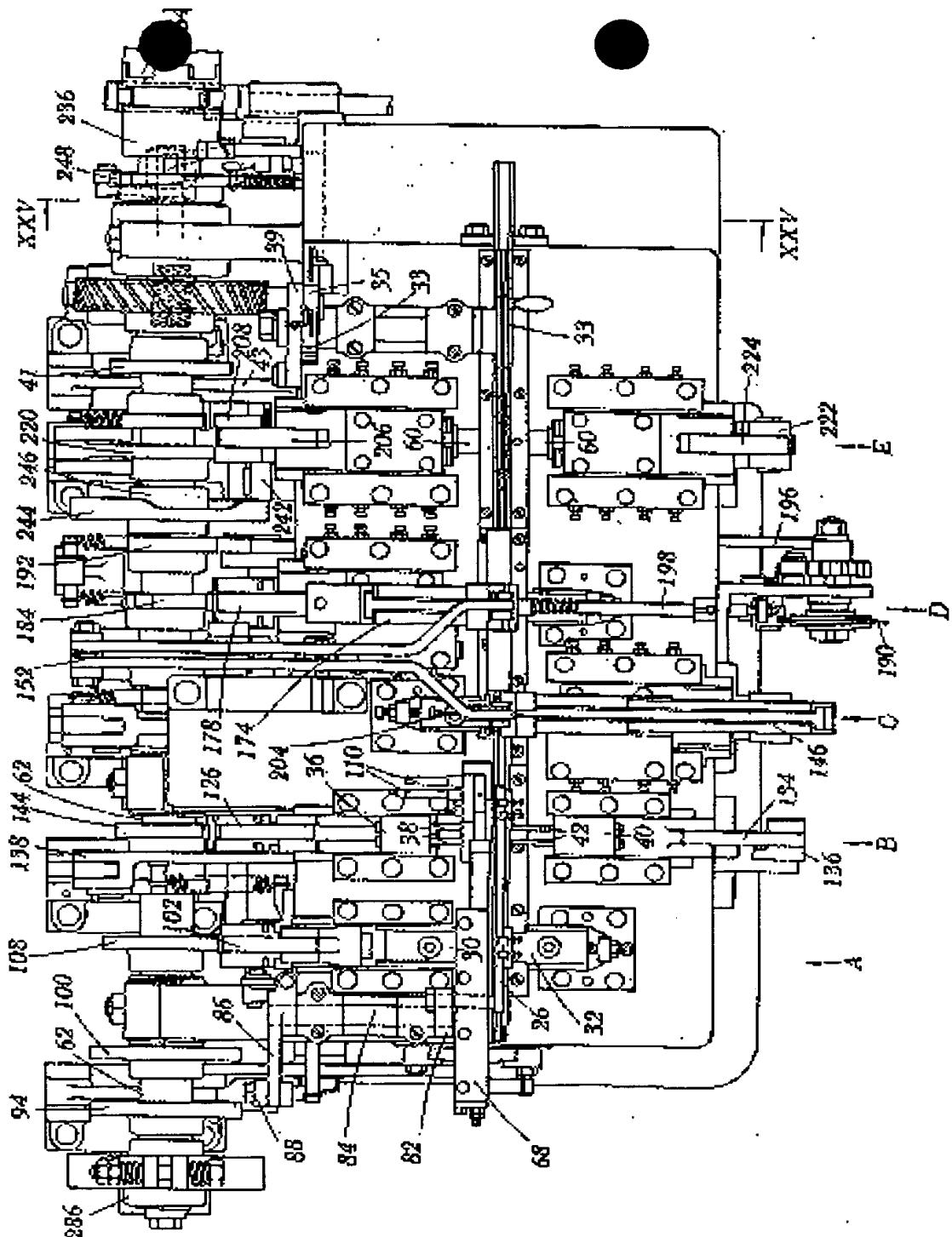


Fig. 7.



Ergonomics



[This Committee is appointed to consider the formation of the Colony]

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Fig. II.

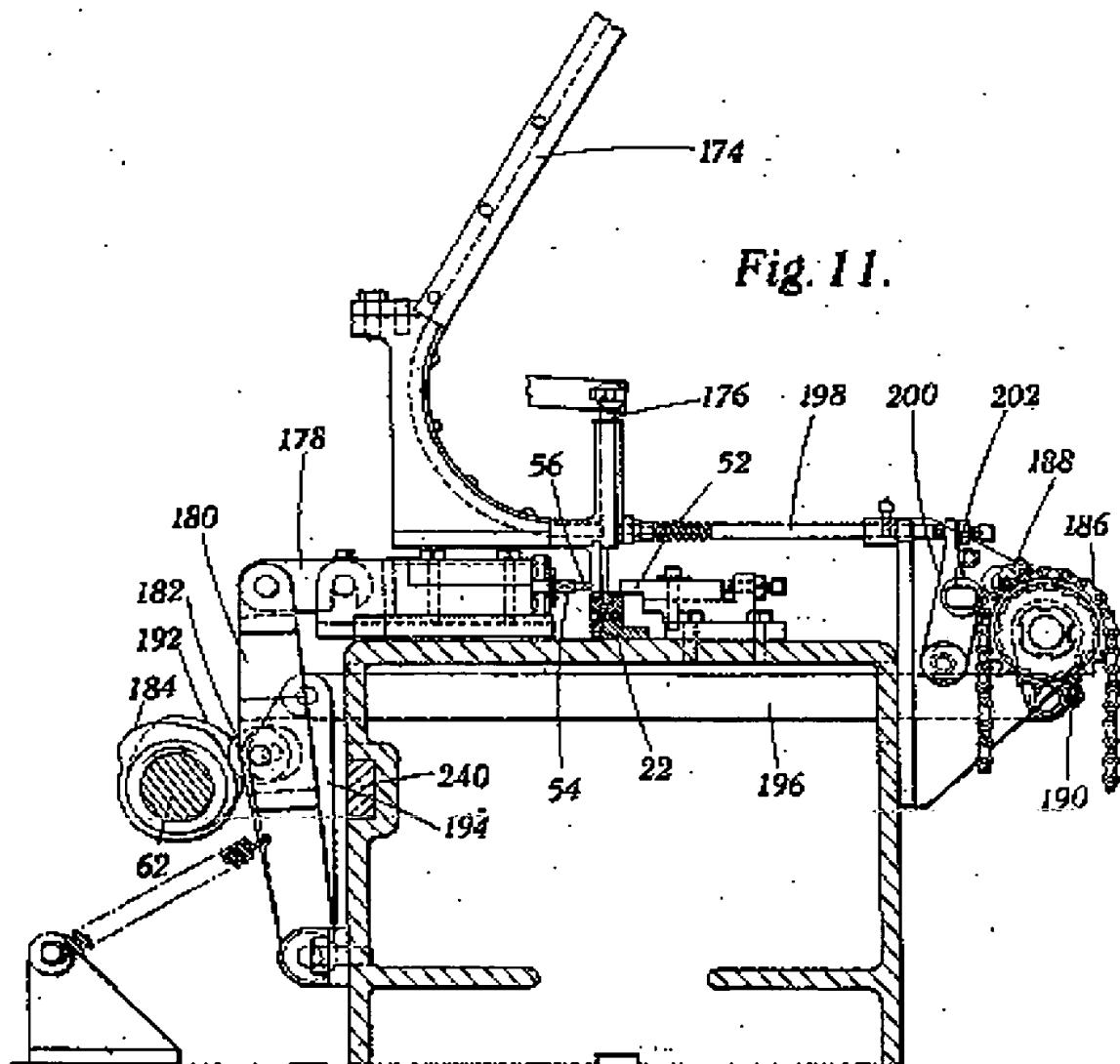


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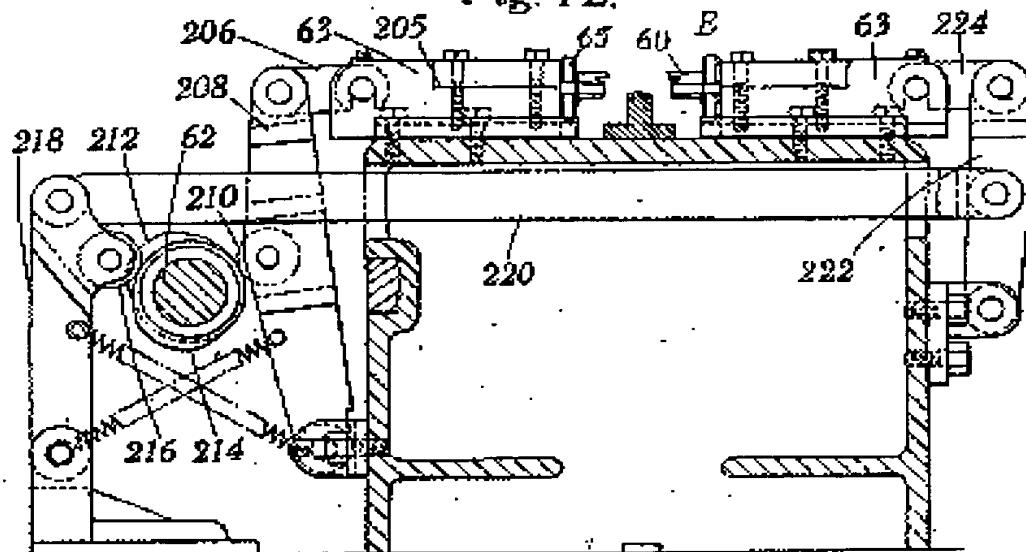
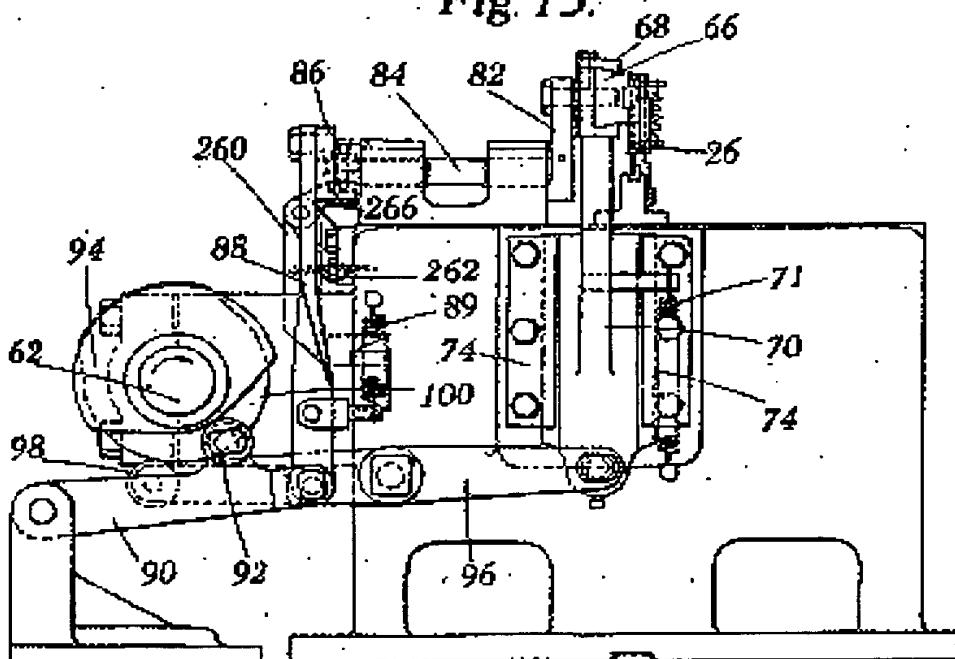
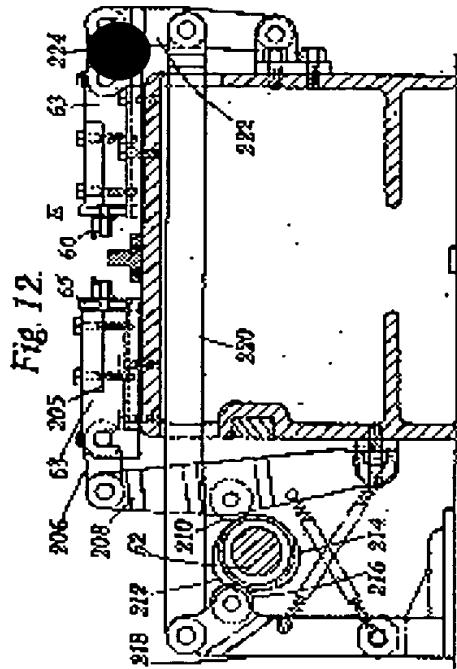


Fig. 13.





12

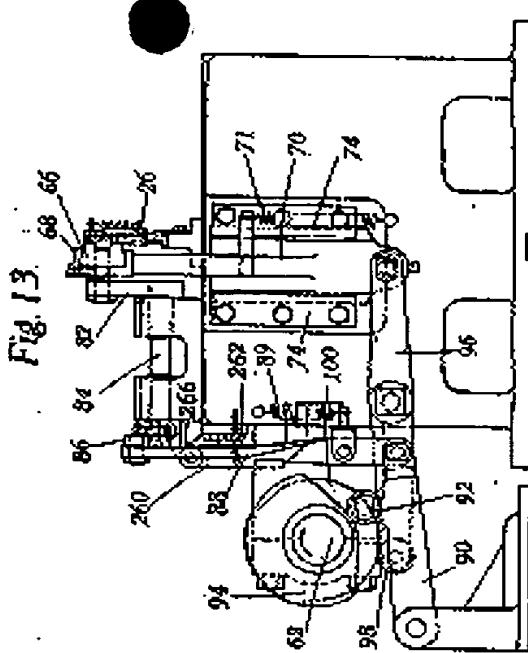
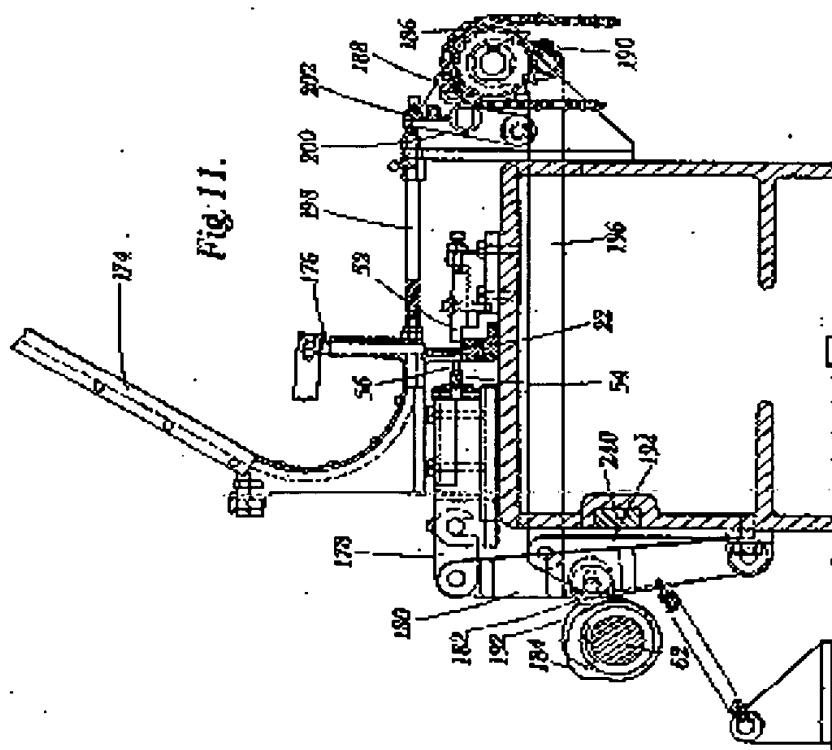


Fig. 13.



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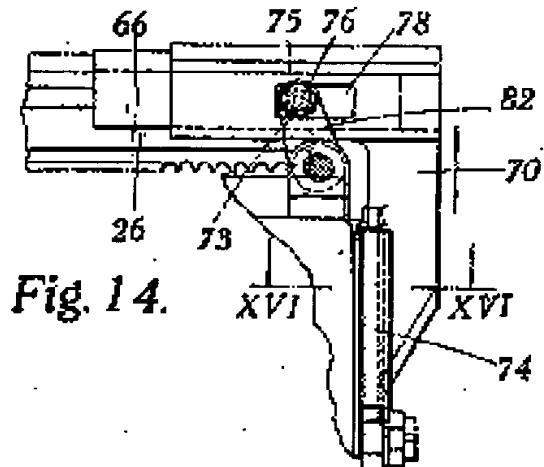


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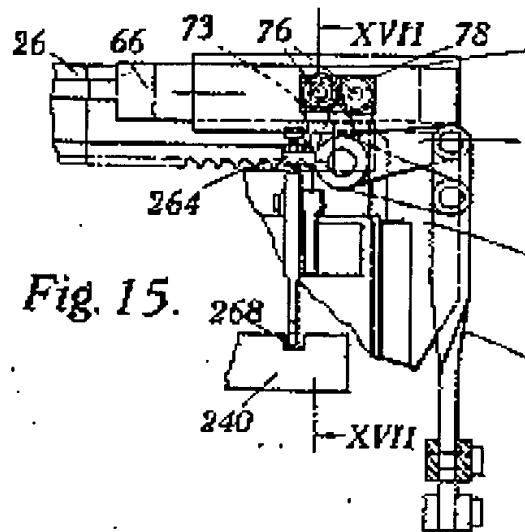


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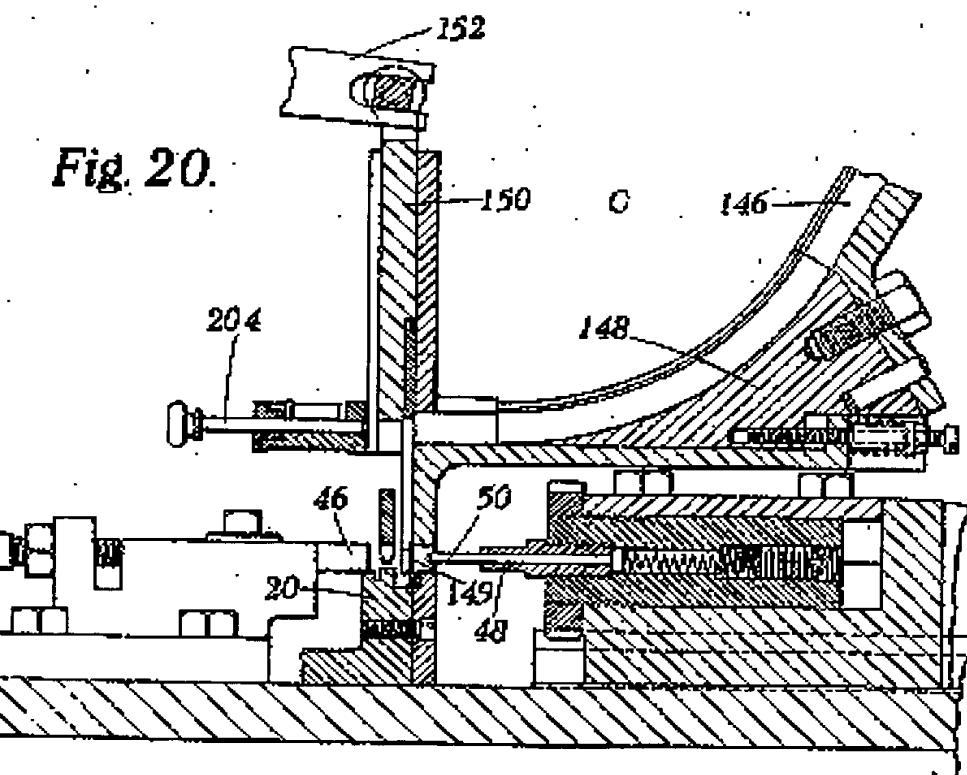


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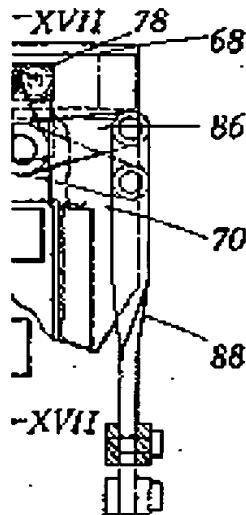


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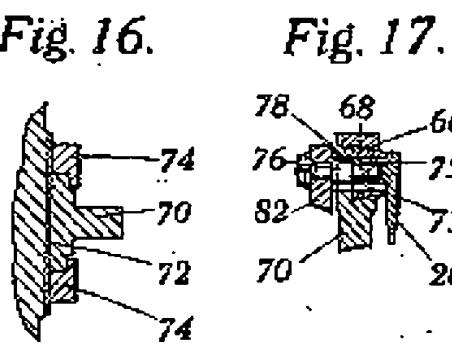


Fig. 17.

Fig. 18.

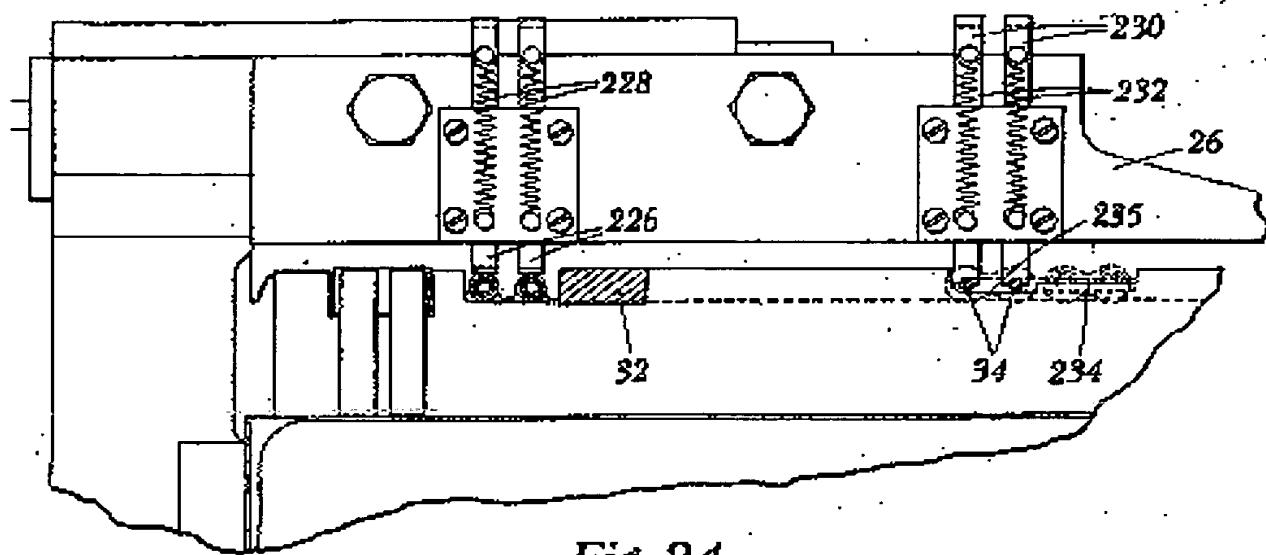


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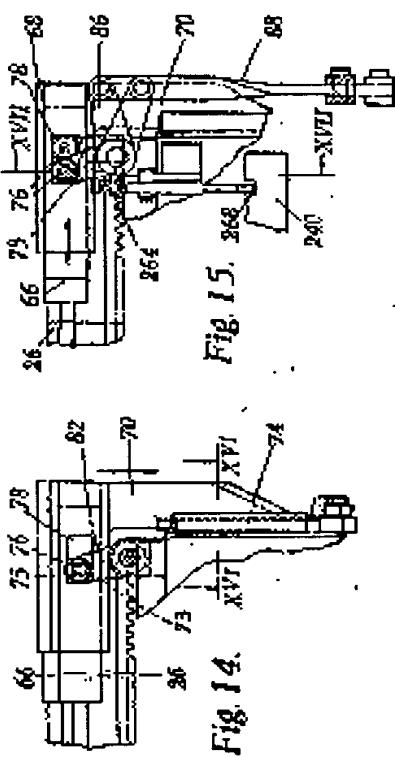


Fig. 14. $\frac{1}{x^p}$

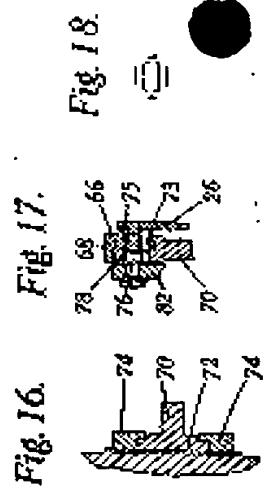


Fig. 16. Fig. 17.

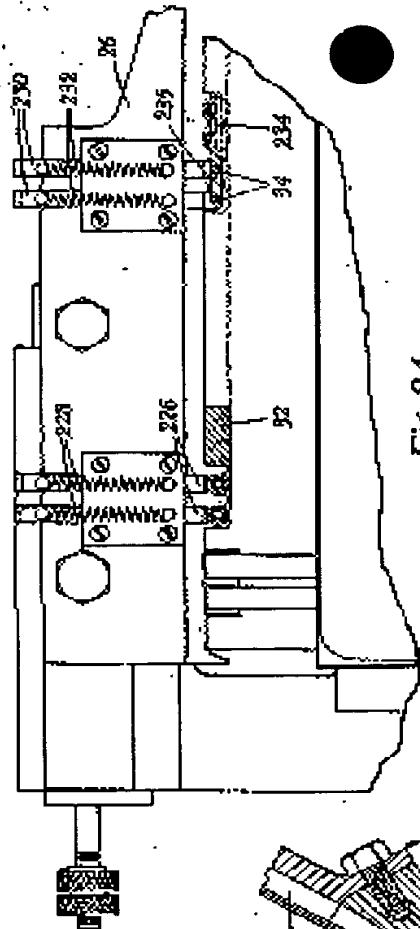


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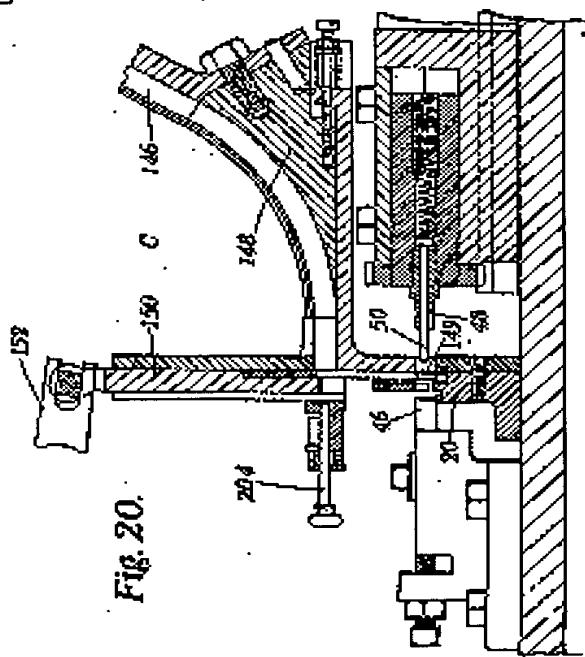


Fig. 20.

Fig. 19.

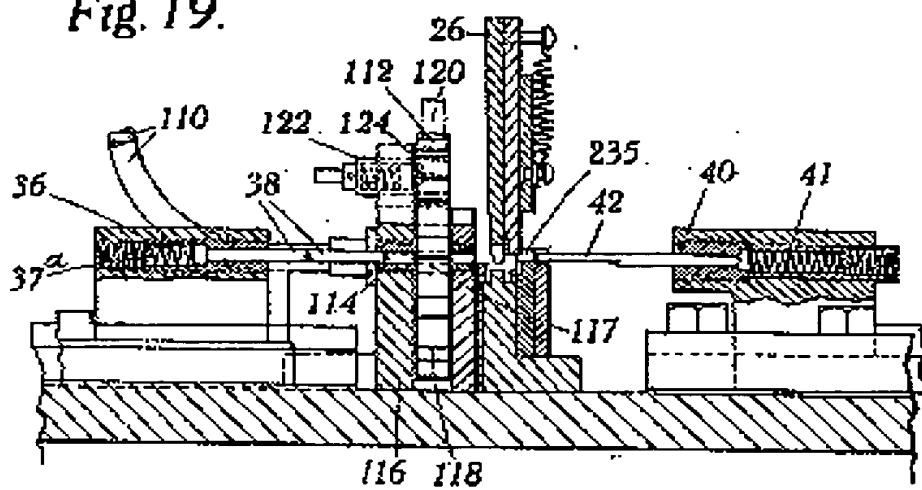


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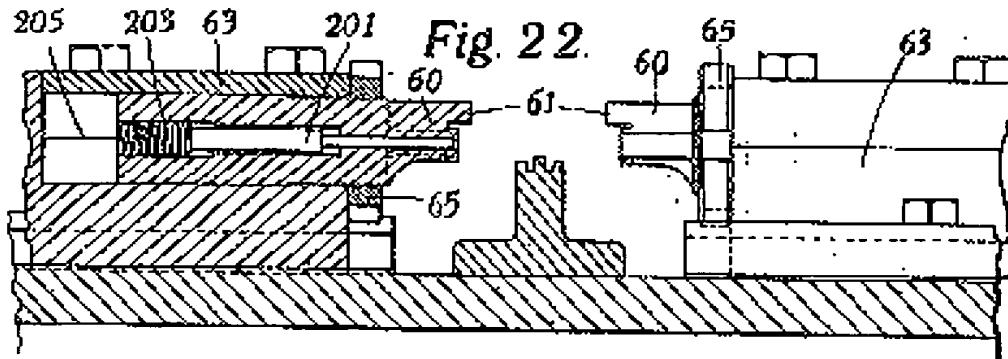
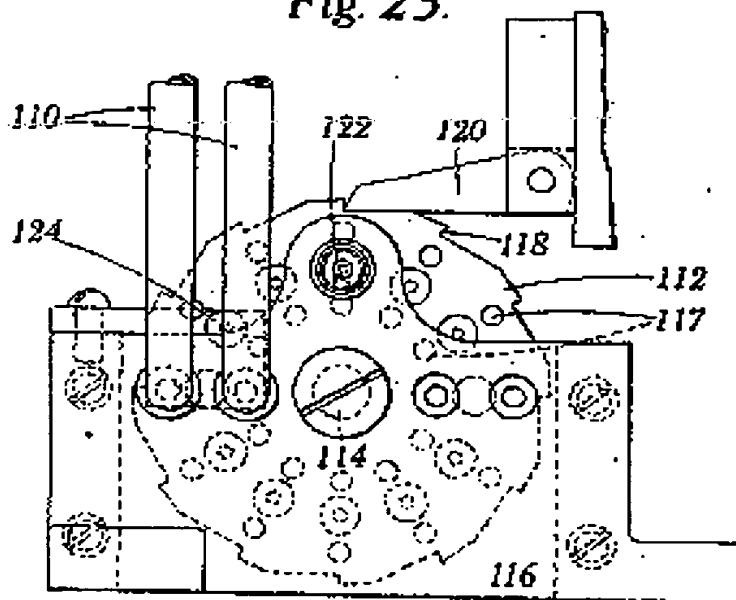


Fig. 23.



[This Drawing is a reproduction of the Original on a reduced scale.]

Fig. 21.

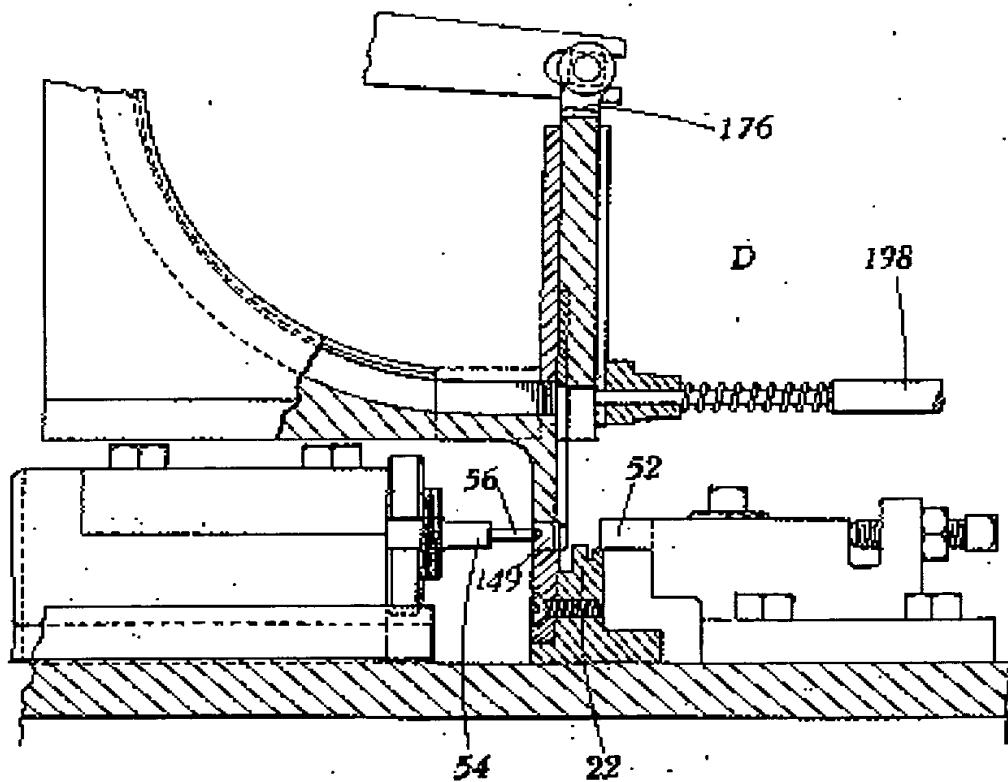


Fig. 29.

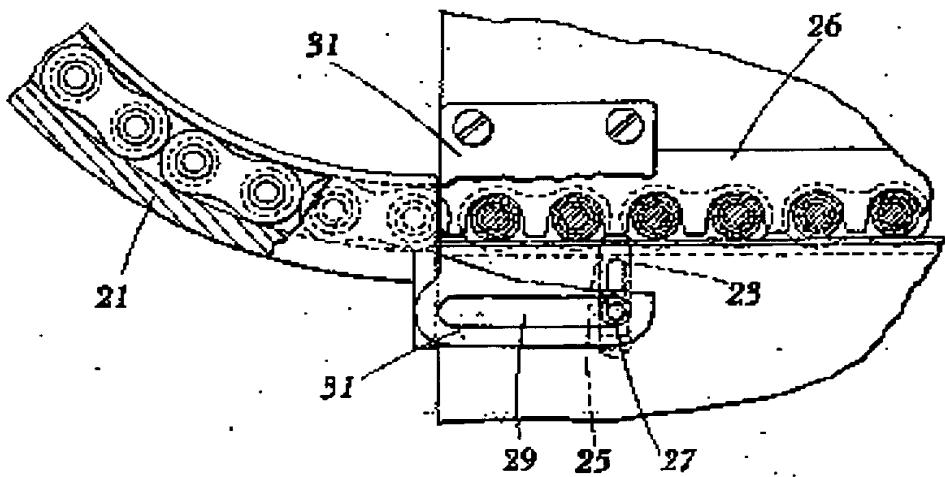
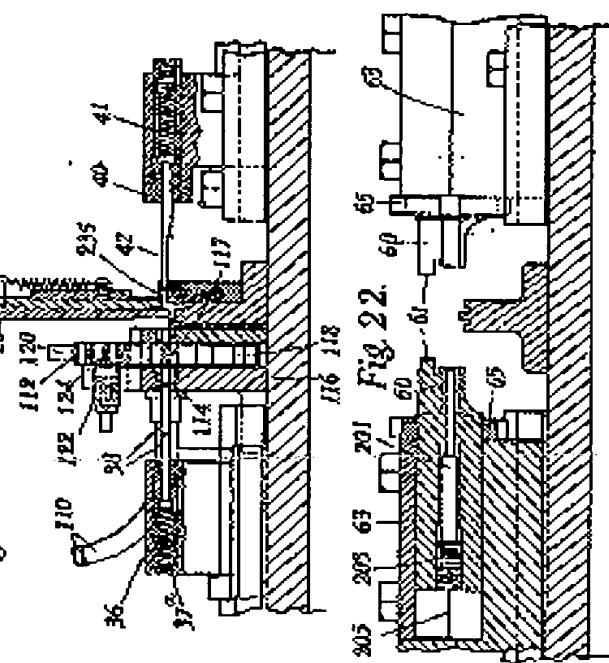


Fig. 19.



This Drawing is a reproduction of the Original on a reduced scale.

Fig. 27.

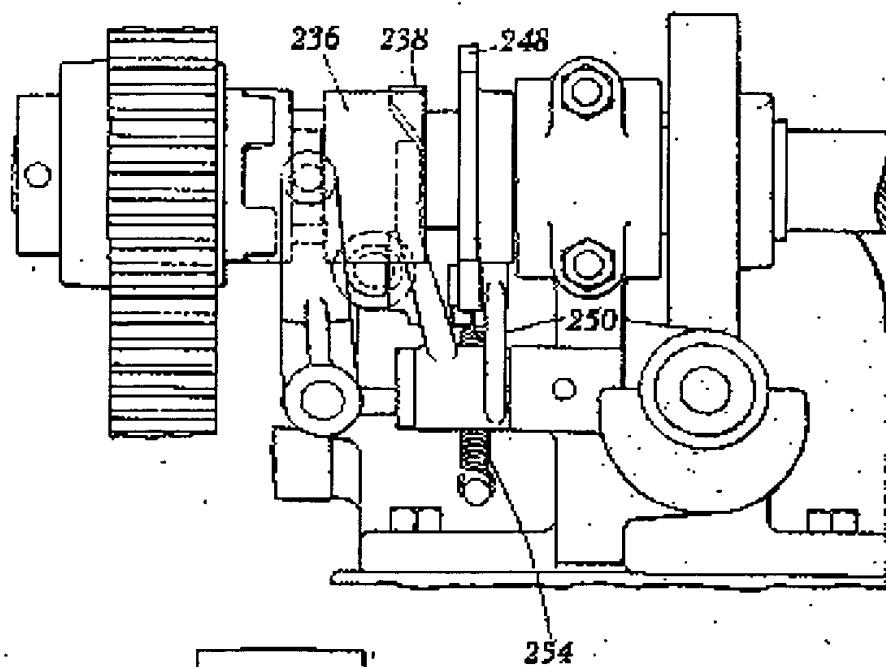


Fig. 26

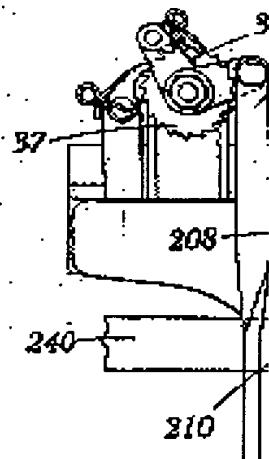
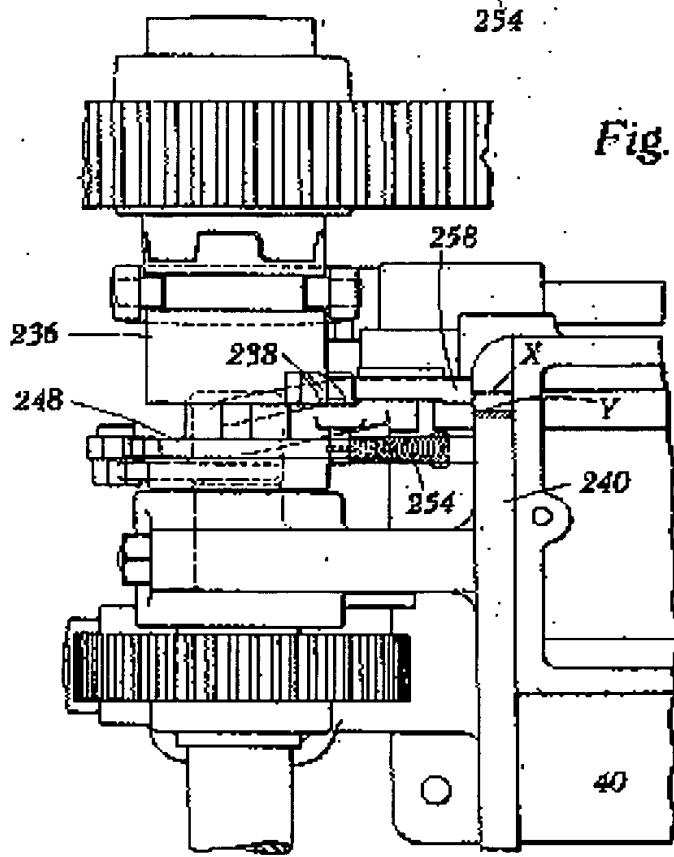


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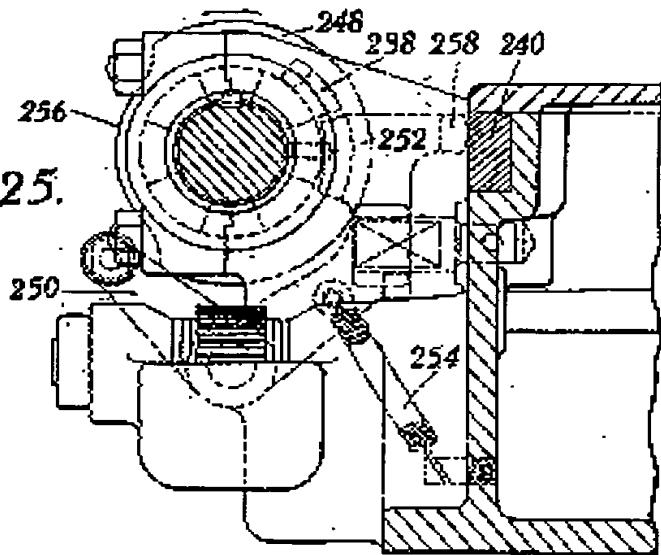
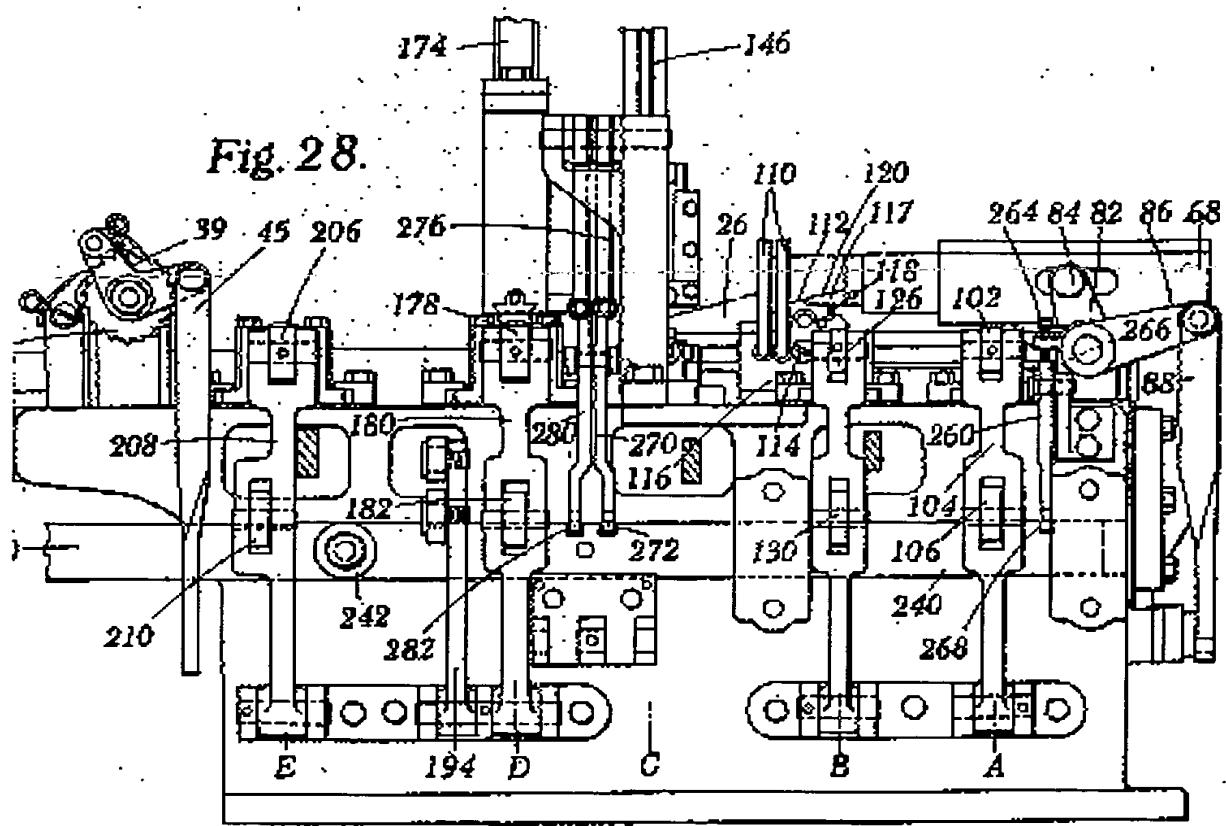
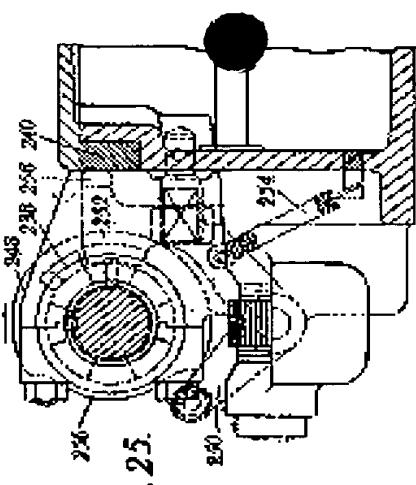
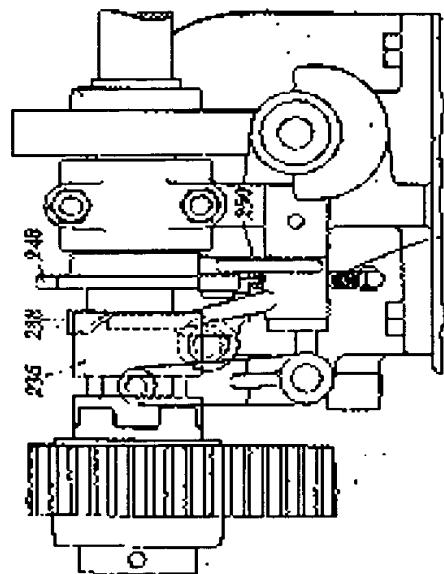


Fig. 28.

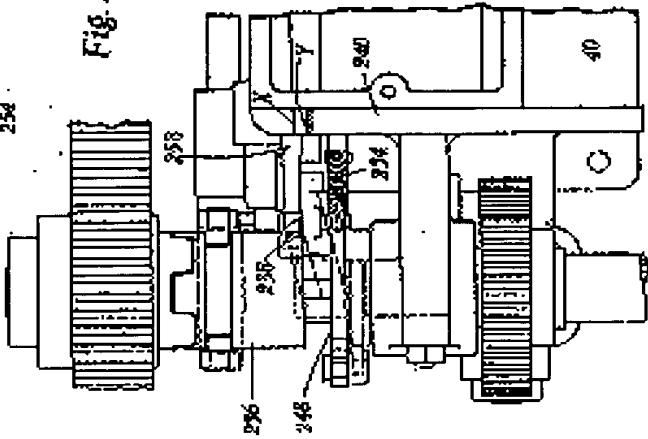




卷二



卷之二



卷之三

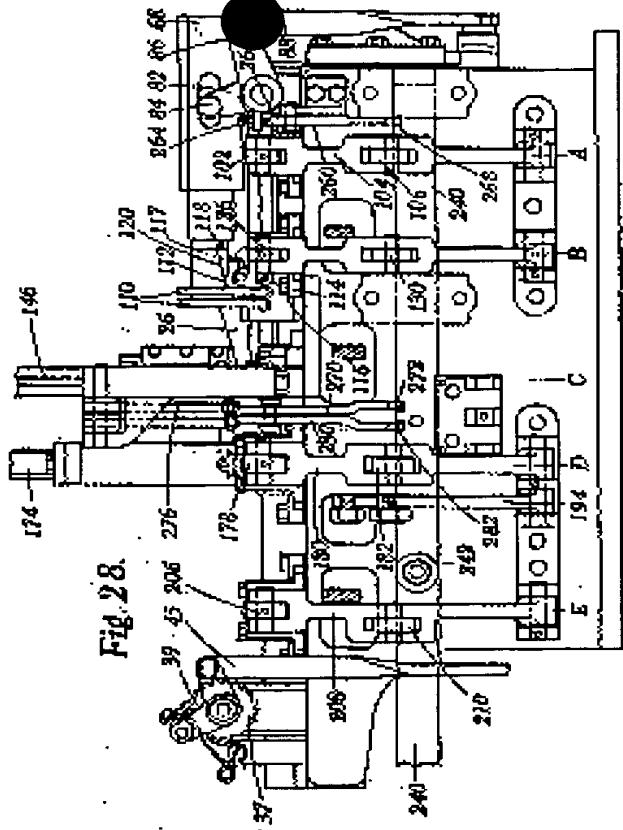


Fig. 25.

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